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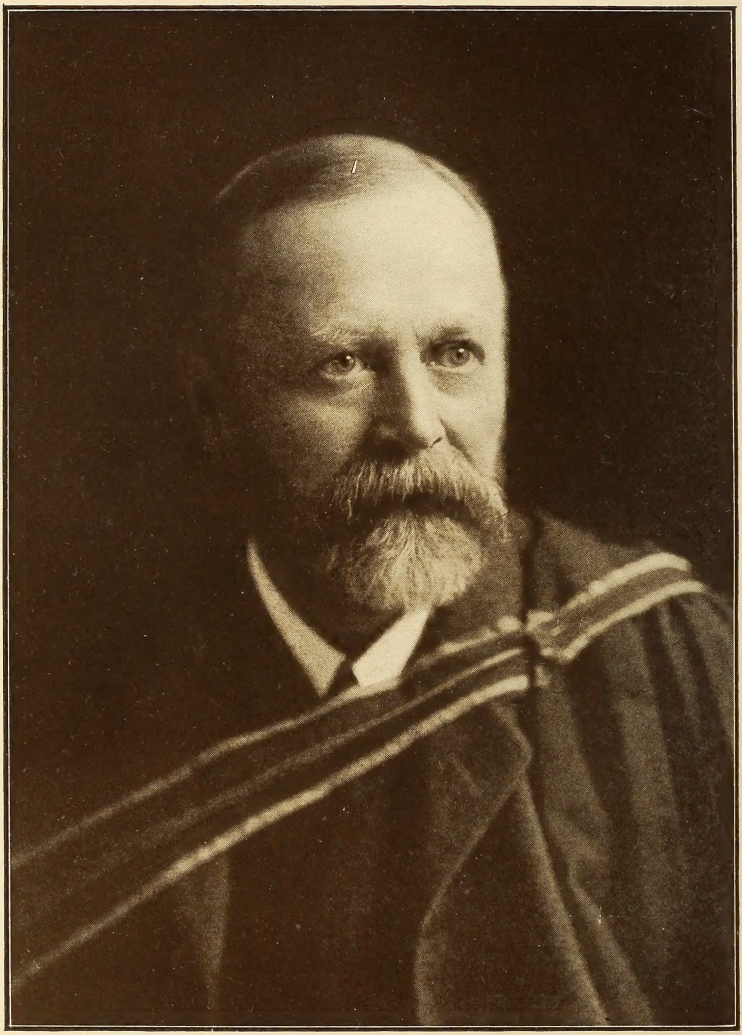

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THE YOUNG CIVIL ENGINEER.

EUGENE W. STERN.

The question which a young man keeps asking himself continually through his college days, and especially just before he graduates, is, "What shall I do next?"

It is a very important question, and one that should be carefully considered, for this is really a critical stage in his career. I shall try to help a little by drawing from my own experiences, confining my remarks to the work of the Civil Engineer, that being the profession I have followed, and I trust that this paper will be freely discussed and criticized by many of our graduates.

Although some of my remarks may apply to the work of the young mechanical and electrical engineer, my opinions in these branches of the profession would be largely that of a layman, and I will, therefore, leave this part of the field to others more familiar with it. In Mining Engineering Prof. Haultain has already covered the ground in his very interesting and valuable paper, recently published in "Applied Science."

Now what line of work or specialty is the young graduate aiming to follow later in life? Does he wish to be in professional practice as a consulting engineer, or be the engineer employed by a railroad or other corporation or contractor, or does he wish to engage in contracting or manufacturing?

This question need not be answered at once, nor can it be until he has had some years of varied practical experience and is able to judge for himself.

Now, I think it will be conceded that to be a successful engineer, or to be really successful in the broad sense in any of the higher callings, a clear knowledge of a large area of life should be acquired, because only this can give breadth and poise and ability to handle large problems and develop in one executive ability and what may be called the ethical qualities, or qualities of leadership, as distinguished from the technical.

Technical qualifications there must be, but these alone will not place one among the chosen of his profession. There must also be the ability to inspire confidence in those desiring to make use of one's services, which confidence can only be based on character, temperament, and training, and the ability to inspire employes with a love of system and order, to maintain discipline without harshness, and economy without parsimony.

There must be endurance of mind and body, and adaptability, thoroughness, efficiency, intensity, and imagination for possibilities. Having thus briefly outlined the necessary qualifications for the successful engineer as they appear to me, let us see now how the necessary preliminary training may be obtained without too much loss of time.

The young engineer, when he graduates at the University of Toronto, has a splendid technical foundation. I do not believe a better one can be obtained anywhere else. He has been thoroughly trained in the fundamental principles of his profession, and no college or university should try to do more than this. There may be post-graduate work along special lines of investigation, it is true, but the *real* post-graduate work can only be done out in the world when he commences to take a hand in the game of life.

The college cannot place responsibility on one's shoulders, whereas as soon as practical work is begun this burden immediately commences to be felt, even if the position held is a very subordinate one.

In college the young engineer has just commenced to learn engineering, having completed only the ground work of his education, and he should begin at the bottom in practical work.

Such was the advice given by Dean Galbraith twenty-four years ago to our graduating class, and my experience has been that there could have been none better.

The first years after leaving college, therefore, should be spent in obtaining experience, as broad as possible, just as the young graduate physician does in going from one hospital to another to improve himself and broaden his training.

In our profession in the early stages, the old motto about "The Rolling Stone" does not apply. While the young engineer does not gather moss he gathers what is much better, experience —experience of the world, experience of men and of things, and his corners get rounded off.

It was just for this reason that in former days the artisan, having completed his term of apprenticeship, started out as a journeyman, to improve himself by travel and variety of experience through contact with the outside world in different places before settling down to his vocation.

The young engineer, therefore, should commence at the bottom, seeking that employment which will bring him out on the work, so that he can see how engineering construction is actually carried on, and how men are handled. He should learn as early as possible to understand men, not only the man with the pick and shovel, the iron erector, or the concrete mixer, but also the man above him. This knowledge cannot be acquired too early, nor can the subject be studied too carefully. It is of much greater importance to his future advancement than technics alone.

He will soon learn some fundamental things. He will find that the day labourer is a human being, having all the human weaknesses of character which we have, perhaps more accentuated on account of his lack of education, but having at the same time a sense of right and wrong. It will be found that he can be reasoned with and under proper leadership takes pride in his work.

It will be found that the man who is able best to direct these men is not the loud-swearing boss, but the quiet-mannered man of firm character, who thoroughly knows his work, and gets it done right without much friction. He has a pleasant word for everyone who is doing his duty. And those who are not doing their duty are not on the job; but let it not be forgotten that this type of leader knows his work thoroughly. In his spare moments he is thinking out methods of how to economize in labor and how to protect his men against accidents, and also how to conserve his employer's interests; he is never found drinking with his men; they *must* respect him.

There are such men as these, born leaders, on all kinds of work—in the backwoods, on construction, and in the shop. Even if one never becomes a contractor nor employs labor, he must learn to appreciate this type of man, because some day when he is high enough up there will be such men under him, and he must know how to win their respect and confidence.

The engineer may be ever so successful as an office man, still some day he will find that his lack of knowledge of men is a very serious obstacle in his upward career, for an engineer to rise to the top must be a leader among men.

My advice, therefore, on starting out in life to the young engineer is that he should not put on any academic frills or patronizing airs. There will be very unpleasant experiences otherwise, and such deportment is a great handicap. He should be modest and thorough. If he is of the right stuff he is bound to come up, without any such useless accessories.

Now, what kind of work will enable one to gain the best experience in the shortest time, for mass of experience alone does not count unless it is broad and varied.

Railroad construction on heavy work, especially in unsettled countries or out-of-the-way places, is, I believe, the very best kind of experience to get immediately after leaving college, because one gets up against first principles, as it were, and sees how things are done from the very bottom.

The life breeds self-reliance and disposition to stand physical hardships, both of which are indispensable, and should be learned early, and the staff is thrown into more intimate relationship than in more settled communities. Besides railroad construction will enable one to see all kinds of work under way—the surveying, the clearing of the timber, earthwork, rock excavation, masonry, concrete, pile-driving, bridge building, track laying, and ballasting, and perhaps tunneling, and it will be a life out in the open air, and the further away from civilization for a time the better the experience.

It may be necessary to commence the work in the wilderness, where even food supplies at first may have to be brought in on the backs of men, exemplifying the earliest and most primitive methods of transportation; and when the work is finally completed and the welcome locomotive appears at the end of track, one engaged in such work will have seen the quick evolution in a few short months, from the most primitive to the most advanced method of transportation, made possible by the gradual progress of science throughout the many centuries, by the knowledge it has given the modern engineer to enable him to control the forces of nature for the benefit and use of mankind.

The lessons thus learned are never forgotten. Often do I find myself recalling with profit some experience gained on my railroad and survey work of many years ago. Even the hardships, the rough life, the plain food (and sometimes even the lack of this), the mosquitos and black flies and other things, are remembered with pleasure, for it was a life of strenuous work along the blazed trail, through the unknown forest and over the hills, and it was a struggle with the elemental forces of nature, and somehow most of us have enough of the primitive man in him to instinctively enjoy what our ancestors had to do.

After having two or three years' experience on railroad or other constructional work in a more or less subordinate position, it is time for a change back to the office; and I would suggest entering a bridge or structural shop, commencing in the draughting-room on shop drawings.

I have suggested a bridge and structural shop for the first experience at the shop, because the training there obtained is fundamental. All the methods are generally developed to a high dgree of refinement, and economy has been very carefully studied both in manufacture and handling of the material.

A large concern is not desirable, because the detailing work is very much sub-divided; however, a few months' experience in such a place would do no harm, if only to learn their methods; but in a smaller concern there is more chance of seeing what is being done in the shop, and very often it is possible to be sent out on the erection.

One will be able to learn the fundamentals of shop work at first hand, such as template and pattern-making, the use of the tools, the handling of the material by cranes and derricks, and the making of erection plant and rigging.

In the office the instruction is also fundamental, and the knowledge gained applies to many branches of engineering outside of buildings and bridges.

It must not be thought for one instant that a draughtsman is an engineer. An engineer must be a draughtsman, just as he must know a good deal about surveying, although a surveyor is not necessarily an engineer.

He should spend every moment of his spare time in watching the work he details go through the shop, and, if possible, should see how it is erected. In my early days I used to put in the time after draughting hours, and even at nights, when the shop was working overtime, in the shops, in order to get posted on the process of manufacturing. No reasonable employer will refuse this permission, and if such is not granted I would advise a change to some other establishment. It has been my experience that the high grade employer was very willing and anxious to have his office men take an interest in such things—he is looking for just that kind of men.

One should be punctual, and not be the last to come in and the first to quit work. He should be diligent and intense in his work, and not loaf or "soldier" like the old fellows—thev remain draughtsmen all their life. He should be thorough, using great care to be exact when necessary. For instance, very often drawings may be freehand sketches if the figures are correct, and all the information given. Shop drawings, nowadays, are largely conventional. It is not really draughting in the broad sense of the word at all; therefore, do not waste time on unnecessary work, but be very careful not to omit information that the man in the shop needs. These remarks do not, of course, apply to scale drawings, which should be carefully and neatly made.

It is of great importance to know how to letter neatly and rapidly. It very often aids one to obtain the first position in the draughting-room, for very likely the first question asked the applicant is, after having stated, that he has had a technical education, is to see samples of his draughting, and if the lettering is done neatly, not only may it get him a position, but secure his advancement much more rapidly from the draughting of shop details to the making of general plans.

It is not necessary or advisable to stay for months on shop details of simple work. After the routine is acquired, one should try to get advanced to more difficult work by winning his employer's confidence in his ability to do it.

He should not get despondent if, by reason of lack of openings, he has to stay longer in a subordinate position than he feels he ought to. He will know, if he is honest with himself, when the time comes to make a change to another employer.

He should be very careful, however, not to change unless for a very good reason. "Stickativeness" at the right time is a valuable asset, but when he does leave he should try his level best to make his departure a source of regret, rather than of joy, to his former employer.

While at the bridge shop the method of organization should be thoroughly studied. It is as plendid opportunity, and should not be lost.

Carnegie was once asked to write an article on Organization. He said he would, but his price would be very high. "How high?" was asked. "Five million dollars," was his answer. The knowing *how* to create such an organization as the Carnegie Steel Co. was worth that amount to anyone who really wanted to know. He further said: "You may take all the machinery, all the plant, all the business, away from the Carnegie Steel Co., but leave me my staff and organization, and I will have it all back in five years." He has often said that his success in life has been due to his knowledge of men.

The knowing how to perfect an organization of human machinery is the most valuable knowledge one can have, and exceeds technical qualifications, but one must know the technics in general to be able to perfect an organization.

One should stay at the shop long enough, if he ultimately thinks of becoming a bridge or structural engineer, to know how to design, detail, build in the shop, and erect buildings and bridges. In my opinion, no engineer is thoroughly competent to *design* unless he knows also how to *construct* the work which he designs.

After being at this work three or four years, and having already been on construction two or three years, the young engineer will have completed the bottom course of his foundation in practical work. He will have been up against first principles, as it were, in both construction in the field and in the shop. He should now look about him, and try to see whither he should begin to steer. He will by this time be able to tell from his own experiences, whether or not he wants to remain a professional civil engineer with some specialty untimately in view or whether or not to go into some line of manufacturing work or contracting.

If at this time he has the means to travel he should spend a year abroad if he intends being a professional engineer, studying European methods and designs. This study should be abroad and far-reaching.

He need not hesitate about engaging in manufacturing or contracting work if he has the taste for it. The technical training and practical experience already obtained are a splendid foundation for this. He will be able to tell when the time comes whether or not he is fitted for this kind of work. One's temperament has a great deal to do with his success as a contractor or manufacturer.

It is of value to know something about bookkeeping and stenography might be valuable, as there are many cases where private secretaries have been able to rise to very important positions.

Another important thing is the keeping of costs of all kinds of work. My practice has been to keep these on regular card index-filing cards. The cost memos should, to be of any value, record not only the amount of the material used and the price per unit for this material, but also the number of hours and rate of wages of the different kinds of labor.

The salary which an engineer receives during his first years is of the least importance. In seeking employment it should be the value of the experience in building his foundation of knowledge which should count, unless, of course, there are special reasons why he should earn as much salary as possible.

I do not mean to say he should be satisfied with a nominal salary or less than what is the prevailing rate of compensation for the same kind of work. This he should obtain, as he would be doing both himself and his profession an injustice if he does not. What I mean to say, however, is that if two positions are offered, in one of which the salary is less than the other, but in which there is a chance of obtaining more varied practical knowledge and ultimately securing greater salary, the former should be selected instead of the latter.

Each position, no matter how subordinate, should be looked upon as a stepping-stone to something better, and every experience, even if unfortunate, be remembered, for such lessons are of great value. One actually learns more from his failures than from his successes.

I have been asked frequently by young engineers if they should accept positions in the tropics in unhealthy districts, and my advice has always been not to do so, for one should not handicap his whole future career by risking his health in his early years, and it is not at all necessary. There are plenty of positions open in Canada and the United States, and there is always a scarcity of thoroughly competent men to fill them.

As to positions in Municipal Bureaus or under the Government, I would advise against these in the earlier stages of practical work, because I think that broad and strenuous experience is better gained elsewhere. It is time enough after the foundation has been thoroughly laid to step into a position under Government, if it is desirable.

And now, just a few words more of advice to the young engineer. He should not drag out the work he has to do, in attempting a degree of refinement which it does not warrant, yet he should not get careless; when he feels that he is getting that way he should shake himself up a bit, or the boss, if he is of the right kind, will surely do so. He should apply the rule of common sense to everything he does. After having completed a design, for instance, let him forget all about the theory and mathematics involved, and try to look at it from the standpoint of practicability—the shop processes, the erection of the work in the field. Let him seek eagerly the results of practical experience, and listen with respect to advice of even the rule-of-thumb practical man who knows his work. He should not try to get another man's job. He should be loyal to the man above him. If he cannot be so on account of this man's lack of integrity, he should either ask for a change or resign. But only a peculiarity of temperament in his employer is not a sufficient excuse for a change. One *must* learn to be tactful and to get along with people both above and below him.

A tendency to change one's position too often without just cause shows a lack of steadfastness.

An employer always wants to know why one seeking employment has changed from one position to another, and the reasons given are carefully considered in the estimate he forms of the applicant's character.

I would advise in making application for positions to clearly but *briefly* state exactly what the previous positions have been, and the experience obtained, and the reasons for leaving each of these.

A copy of a testimonial from each employer should be sent with the application. A personal interview is always to be desired if possible, as it enables the employer to "size up" his man.

The young engineer should associate himself with the local engineering club if one happens to exist, and should early join the Canadian or American Society of Civil Engineers, or both, and keep fully abreast of the times in technical matters. He should mix with those in other professions and with business men, and become known in the place where he lives. Besides, he should not neglect his general education, for after leaving college he has only commenced to be educated in the broad sense. His reading should be as diversified as possible—in history, economics, and general literature, so that some day he may become a well-balanced all-around man, not only a credit to the noble profession he has chosen for his life's work and to his Alma Mater, but also to the community wherein he lives.

[This paper of Mr. Stern's cannot but be of mutual interest to the undergraduate and young civil engineer. Mr. Stern and the editor are anxious to have the article freely discussed. Applied Science will print the discussion. Mr. Stern will sum up and complete the same in the April number. Next year it is intended to take up the discussion of "The Young Electrical and Mechanical Engineer."—Editor.]

A NOTE ON THE RELATION OF THE MINING ENGINEER TO THE PUBLIC.

H. E. T. HAULTAIN.

"The learned professions" was a term of our fathers. They had the Church and Law and Medicine and to these they perhaps added as an "honourable" rather than as a learned profession that of Arms, and this covered the list of the professions as distinguished from other walks of life. We still use the term and in an unthinking way with about the same limitations. But —nowadays, is not engineering one of the professions?

What is a profession? Who defines the word? What is not a profession? In these days what is not learnéd? Many trades call for mental activity of a higher order and for more knowledge than did the professions of our grandfathers. Should we use the term or drop it? Should we modify it by the words learned or honorable or both? In contradistinction to what other terms should we use it?

I am in the dark. I grope. I would grasp that quality or that function of engineering which makes it one of the professions. But perhaps it is not a quality nor a function, nor even an essence, but rather a blending so subtle as to defy isolation or definition. My engineering spirit rebels. I not only want to isolate this something but I want to measure it and having failed my engineering spirit shies away, retires in disappointment at failure, and goes back, content, perforce, with the overalls and the rule and the things with which they fit. But we really are with the Doctors and with the Divines and with the Lawyers. But how? Are we not learned? We are honourable. Are we? Is that the essence that we must isolate and measure. Who defines honour? If it is a function how do you express it. If it is a quality how do you measure it. Is it also a complex blending?

Perhaps the term profession *should* be shied away from. Are there not other words that we shun? Honour, for example, yes! and gentleman. In all probability their undefineableness preserves their sacredness and their strength, yes, and strange as it may seem perhaps their educative value. Gentleman is often a much abused and a hateful word and so is perhaps honourableness. But still they have a great educative value and we must not lose them.

Is it not perhaps in public service and honourableness that are to be found the main characteristics uniting the professions? Learnedness counts for little in these days where there is high mental activity in so many directions. Public service alone is not a characteristic of the professions, though Kipling tells us that Lalun's was the most ancient of professions.

But these are wanderings. I want to bring the mind of the Engineer and more particularly the Mining Engineer to the question of public service and honourableness in his profession and this can be done by the consideration of a particular phase of his work. The Consulting Mining Engineer sits in his office waiting the call of the public just as do the Doctor and the Lawyer. He has to live so he charges a fee as do the Doctor and the Lawyer. But before the fee is arranged for, and even without a fee the Doctor and the Lawyer and the Engineer are honourable men to whom personal secrets may be safely told. And the best of information and advice is at the service of the would-be client.

The client gets a disinterested opinion to the best of the ability of the Lawyer or the Doctor or the Engineer. Disinterested was the word I used. That is the quality of honourableness that we can isolate and measure. If disinterestedness is not the all of honourableness it is the main ingredient of the blend.

The professional man considers only the good of his client —if he cannot do so he does not accept the client as his. But is this all? Another client visits the Doctor and is prepared to pay a large fee and demands the best treatment at his hands, but he finds this client has smallpox and immediately his attitude towards him is somewhat changed. His first thought is not for the client but for the public. He will do the best he can for his client but subject always to the good of the public. The client cannot be allowed to travel to his friends—he cannot have the most comfortable of quarters—he cannot even have his secrecy and privacy entirely preserved. The public is the Doctor's first client, and takes right-of way. The Doctor's will in this respect is strengthened by the law of the land, but the law had its inception under the guidance of the Doctors.

The Lawyer's philosophy is not quite so fine. The Lawyer is a special pleader and will accept as a client an enemy of the public good and will protect him from the public.

Is this quite true? Nominally, No! but in reality—yes! But with this difference, the Lawyer does this only in open court where the public also has its Lawyer to defend itself and the game is played in the open. But we must remember that the Lawyer is a special pleader and presents his case from his client's point of view even to the extent of withholding truths and distorting evidence.

This is much below the standards of the Doctor and yet is compatible with honourableness for this reason and only this reason that it is done publicly and openly in the presence of an opposing counsel and a controlling, judgment giving judge.

How is it now with our Engineer and his client? A client says: I am thinking of buying B's mine. Will you examine and report on it. The Engineer does so and condemns the mine, and advises A not to purchase. B goes to the Engineer and says: I want to sell my mine to the public at a large figure. I am going to promote a company and I want an Engineer's report for the prospectus.

Now, what is this Engineer going to do? Is he a special pleader taking his client's fee and making the best of his client's case by withholding some truths and even distorting some evidence that his client may sell his mine to the public? No! most decidedly, No! Unfortunately, he cannot publicly proclaim the man as does the Doctor with his case of smallpox. All he can do is to refuse a garnished report. Now here is the danger and the trouble of it all. The man with the no-good mine goes to another man who says: I am an Engineer; I will make you out your report. This other man may have no claim whatever to be an Engineer but the public does not know this. But there are others who have been Engineers who now do this kind of thing because of greater or easier gain, but they are the prostitutes of the profession, and they should be ostracized.

The Doctors have their Medical Council—the Lawyers have their Law Society and they tell the public who are Doctors and who are Lawyers and they exercise some control over the standards of their professions. But in Canada we have no Society of Mining Engineers corresponding in any way with the Law Society and we have no publicly recognized ethics of Engineering. Is not the larger duty before the Engineer in all branches to-day the recognition of the public service and of the honourableness of his profession?

PLATE GIRDER WEB SPLICES

C. R. YOUNG, B.A.Sc.

Except in the case of plate girders of small size, it is generally impracticable, and sometimes impossible, to construct a girder without one or more web splices. The rolling mills do not manufacture plates over certain extreme lengths depending upon the width and thickness, and these limits cannot, therefore, be exceeded in design. The price per pound of the extreme sizes of plates is at the same time higher than for those of more moderate dimensions, so that the use of several plates with splices might be a cheaper arrangement than employing a single plate. It also frequently happens that the necessity for despatch in the work does not permit waiting for the delivery of full-length plates from the mills, and so the girder is made up of shorter ones which chance to be in stock at the time.

The splice provided at a given section must obviously be capable of safely resisting whatever stresses exist in the web at that section under the most unfavorable condition of loading. What this latter is must be ascertained by calculation. In the case of girders carrying moving loads it may chance that the splice will be more heavily stressed under the maximum shear at the section with the corresponding moment than under the maximum moment with the corresponding shear. This is not likely to occur, however, for splices nearer the centre of the girder than one-quarter of the span length, and, as will be shown later, the splice will generally be amply strong if designed for the maximum moment sustained by it, without regard to the effect of the corresponding shear. In keeping with the common practice of making the details of a structure such as to develop the full strength of the main material, web splices are, however, frequently designed to develop the full capacity of the net section of the web, and not merely to resist the calculated stresses that might arise at the joint.

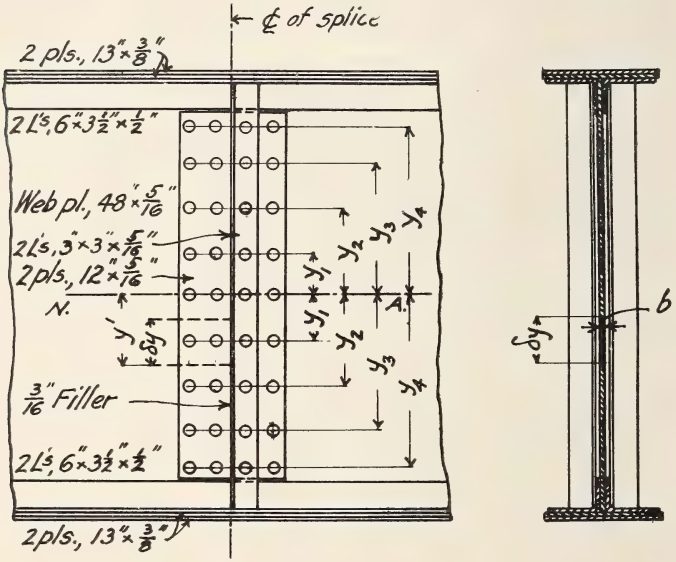

Fig. 1

When the arbitrary assumption is made, as some specifications require, that the web is not to be regarded as resisting any of the bending moment, the splice need not be proportioned to take bending stresses, but merely the shear at the section. It then consists, as shown in Figure 1, of two vertical plates, one on each side of the web, extending from the inside edges of one pair of flange angles to the inside edges of the other pair and having not less than two vertical rows of rivets on each side of the splice. The two plates are generally chosen to make up a combined thickness of one and one-half times to twice the thickness of the web. A pair of stiffener angles are commonly placed at the splice to give effective lateral support.

Although the splice is required to transmit only the vertical shear across the joint, one designed in strict conformity with this requirement would not be allowable since fewer rivets would be employed than practical considerations of rivet spacing will permit. This may be seen from a discussion of the splice illustrated in Fig. 1, which occurs at 12 feet from one end of a girder 40 feet centre to centre of bearings carrying a total static uniform load of 5000 pounds per lineal foot. The total shear at the joint is 40,000 pds. and this must be resisted by the two rows of rivets on either side of the splice. The assumption is generally made that this shear is uniformly distributed among the rivets sustaining it, which is probably not far from the truth. In addition to the direct effect of the vertical shear there is a turning moment brought to bear upon the rivets on either side of the joint equal to the vertical shear multiplied by the distance between the centres of gravity of the two groups of rivets on opposite sides of the splice. This arises from the necessarily eccentric application of the vertical shearing force. The effect is not large, however, since the splice generally constitutes a deep connection, and it is generally neglected. Using ¾-inch rivets and assuming the safe shearing and bearing stresses for rivets at 11,000 and 22,000 pds. per sq. in. respectively, the least value of one ¾-inch rivet is found to be 5160 pds., its bearing value on the 5/16-inch web plate. The number of rivets required on one side of the splice would therefore be 40,000 ÷ 5160 = 8. Since, however, the vertical rivet spacing should properly not exceed 16 times the thickness of the splice plates or 5 inches, using 5/16-inch splice plates, 18 rivets must be used on each side of the splice instead of 8. Thus it is necessary, practically, to make the splice much stronger than the requirements of stress-resistance would dictate, in this case almost enough to provide for the total end shear, or in other words, enough to develop the full capacity of the web. The total end shear being 100,000 pds., and one rivet having a value of 5160 pds., only 19 rivets would be required for this service, and therefore it is apparent that the splice might as well be at once designed to equal in strength the net section of the web plate.

If in the design of the girder the reasonable assumption is made that the web plate develops the full moment of resistance of which it is capable by virtue of its net area, the web splices must be proportioned to transmit bending, as well as shearing, stresses across the point. Assuming that the bending stress in the web increases uniformly from the neutral axis to the most remote fibre, it follows that the stresses on rivets in a web splice due to bending increase uniformly from zero at the neutral axis to a maximum at the rivet most remote from that axis. The resisting moment which a rivet will therefore exert against the bending moment will vary directly as the square of its distance from the neutral axis, since the resisting moment equals the resisting force generated by the rivet multiplied by its distance from the neutral axis. Hence it is evident that the rivets farthest away from the neutral axis are more effective in resisting bending moment than those nearer it and that those lying on the neutral axis have no value as far as resisting moment is concerned.

For this reason the type of splice shown in Fig. 1 generally proves inadequate where bending stresses have to be provided for, unless a great number of rivets are used by adopting very close vertical spacing or widening the splice plates and introducing another line of rivets on each side of the splice. Such an arrangement is highly uneconomical, for a large proportion of the rivets—those near the neutral axis—have very little value in resisting bending stresses. More efficient means have to be devised, therefore, for splicing webs in girders of the kind under discussion.

A form of splice frequently used in such cases is that shown in Fig. 2, and which has been designed for the girder of Fig. 1, the section of which is revised in conformity with the assumption that one-eighth of the gross area of the web may be considered as flange area. Instead of carrying the two vertical splice plates from flange to flange, two horizontal splice plates are placed on the web just inside the inner edges of each pair of flange angles and the vertical plates terminate at the inside edges of the horizontal plates. The latter are generally of about the same thickness as the former, that is the two plates on opposite sides of the web together make up a thickness of one and one-half times to twice the web thickness. By the employment of a splice of this type it is possible to locate a large percentage of the rivets used at a considerable distance from the neutral axis where they are highly effective in resisting bending moment. So much resisting moment is developed by the rivets in these horizontal splice plates that some designers assume that it is all generated by them and that the vertical shear is wholly resisted by the rivets in the vertical splice plates, the numbers of rivets used in these plates being arrived at on the basis of the foregoing assumptions.

While this is an ideally simple arrangement from the standpoint of the designer, it has the disadvantage of giving rise to secondary stresses of considerable magnitude in the web. The provision of a stiff, closely-riveted splice just inside each pair of flange angles has the effect of throwing most of the bending stress into the horizontal splice plates because of the principle that a load which has to travel over several paths divides itself up among these paths directly as their rigidities. This concentration of bending stress into relatively small areas of the web cross-section produces an effect of somewhat the same kind as that which would be produced if single pins were used at the ends of the horizontal splice plates and the web were not reinforced at these points. Such localizing action is evidently not to be commended.

That the concentration of large numbers of rivets at certain points in the web splice is not consistent with the assumption of uniformly-varying bending stresses on the web section may readily be shown. Referring to Fig. 1, the resisting moment of any element of the web of height δ and thickness b is equal to $\frac{f^1}{y^1} I^1$, where

f^1 = the stress in pds. per sq. in. on the extreme fibre of the element.
y^1 = the distance from the neutral axis to the extreme fibre of that element.
I^1 = moment of inertia of the cross section of the element about the neutral axis of the girder $= I + Ay^2$.
I = moment of inertia of cross-section of element about an axis through its own centre of gravity.
A = sectional area of element.
y = distance of centre of gravity of element from neutral axis of girder.

Since the moment of inertia I of the small area A about its own gravity axis is negligible compared with the term Ay^2, we may write $I^1 = Ay^2$, approximately. Now since uniform variation of stress has been assumed

$$\frac{f^1}{y^1} = \frac{f}{\frac{d}{2}}$$

where f = permissible stress at the extreme fibre of the web, which is assumed to be at the centre of gravity of the flange.
d = effective depth of girder which is assumed to be equal to the depth of the web.

The resisting moment of the element therefore equals $\frac{2\,A\,f\,y^2}{d}$

Now since the stress on rivets due to bending effect increases directly with the distance from the neutral axis, if a rivet in the gauge line of the flange angles have a safe value of r, then the greatest permissible stress on a rivet one inch from the neutral axis would be $\frac{r}{\frac{d}{2}}$, assuming that the gauge line is at the same distance from the neutral axis as the centre of gravity of the flange. A rivet at a distance y from the neutral axis would then carry a stress of $\frac{2\,r}{d} \times y$, and its resisting moment would be $\frac{2\,ry^2}{d}$

The number of rivets in the element should therefore be

$$\frac{2\,A\,f\,y^2}{d} \div \frac{2\,ry^2}{d} = \frac{A\,f}{r}.$$

This quantity is independent of the value of y, and therefore the spacing of rivets should be uniform from top to bottom of girder in order that the assumption of uniformly-varying stress may be realized. Though the concentration of rivets as far as possible from the neutral axis in a splice of the type shown in Fig. 2 is economical in the matter of riveting, this saving is effected at the expense of preventing the web at the splice from acting in the same manner as elsewhere, and probably overstressing it at certain points.

This type of splice has at the same time the minor defect of not presenting a very pleasing appearance to the eye. A suggestion of "patching" is borne to one who is not oblivious of all save the requirements of strength and dimension.

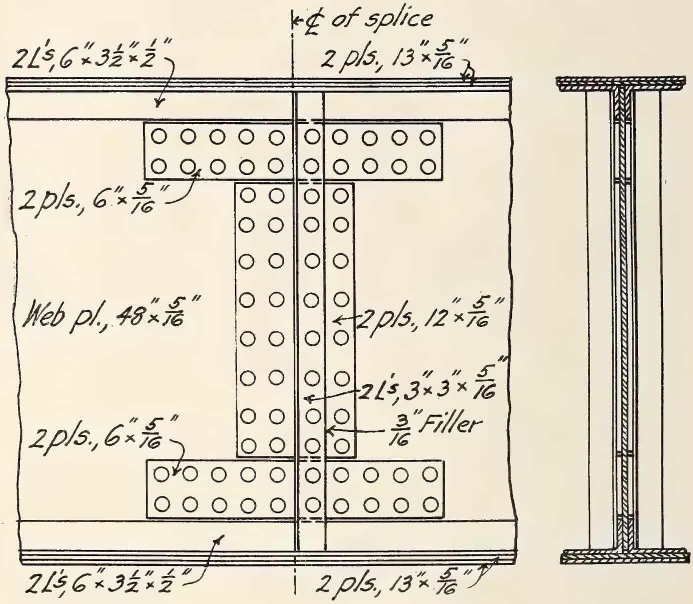

Fig. 2

A more satisfactory form of splice is that shown in Fig. 3. In this, the vertical splice plates, which are of similar thickness to those used in the types described above, run from flange to flange and horizontal splice plates are put on either side of the vertical legs of the flange angles. The rivets in the vertical splice plates are spaced about 4 inches apart vertically and as uniformly as possible, the shorter spaces, if any, being placed at the ends. Using two rows of rivets on each side of the splice in these plates is generally not sufficient to develop the full bending value of the web plate, and instead of introducing another row, the horizontal splice plates are employed. If the full value of the web were developed by the rivets in the vertical splice plates, the splice would not be well designed, for the part of the web lying between the two vertical legs of the flange angles should be spliced as well as the part covered by the vertical splice plates. Obviously the horizontal splice plates should be strong enough, and contain enough rivets, to develop the difference of resisting moment of the net section of the web and of the splice as provided by the vertical splice plates and the rivets in them. It might be urged that where more than four rivets were required in the horizontal splice plates on each side of the splice (see Fig. 3) to develop this difference of resisting moment, it is equivalent to concentrating the rivets at this point. In answer it can be said that the part of the sectional area of the horizontal splice plates and of the rivets in them which is not utilized for splicing the portion of the web between the vertical legs of the flange angles may be regarded as affording an increment in flange section in the region of the splice. Increasing the flange section at the splice makes is unnecessary to splice the web up to its full bending value and whatever resisting moment is developed by this increment of flange section need not be provided by the web splice proper.

The objection is sometimes raised against the form of splice under discussion that the horizontal splice plates necessitate additional fillers under the stiffeners which come at the splice or crimping different from that used for the other stiffener angles. These disadvantages are never serious and are preferable to the use of an arrangement by which only the part of the web between flanges is spliced either by the use of three vertical rows of rivets or two rows and horizontal splice plates on the web with the attendant concentration of rivets near the inner edges of the flange angles. Even if additional fillers have to be used under the stiffener angles at a splice of the form advocated, its superior economy of material and rivets over the splices of the two other forms mentioned above will nearly counterbalance the increase of weight necessitated by the extra fillers. Very often the crimping of the stiffeners at the web splice, if they be crimped, is, or may be made to be, the same as for the other stiffeners. This is possible when the horizontal splice plates can be made of the same thickness as the vertical splice plates, which is frequently the case.

One of the reasons given by some authorities for not using this type of splice is that the rivets in the horizontal splice plates on the vertical legs of the flange angles are put under double duty. Except in the case where the splice occurs at a point of zero shear, a certain number of rivets per lineal inch are required in the flange angles in the region of the splice for the purpose of transferring the increment of flange stress from the web to the flange angles and plates, and therefore the rivets in the horizontal splice plates are only *partially* available for the purposes of the web splice. There is no reason, however, why the rivet spacing in these plates cannot be shortened up, so as to accommodate such a number of rivets, that allowing a *part* of each rivet for purely flange riveting purposes the requirements in this respect would be fully satisfied while at the same time the remaining *parts* of rivets would fully provide for the web splice.

To illustrate the method of designing a web splice of the last type discussed, the splice shown in Fig. 3 will be investigated in detail. This joint occurs 15 feet from one end of a girder 60 feet centre to centre of bearings, carrying a total static uniform load of 6000 pds. per lineal foot. It was figured on the assumption that one-eighth of the gross area of the web acted as flange area, the permissible fibre stress in bending being taken at 16,000 pds. per sq. in. net section. The safe shearing stress on the web was taken as 10,000 pds. per sq. in., net section, the rivets being ⅞-inch in diameter and the assumed safe shearing and bearing stresses being 11,000 and 22,000 pds. per sq. in., respectively.

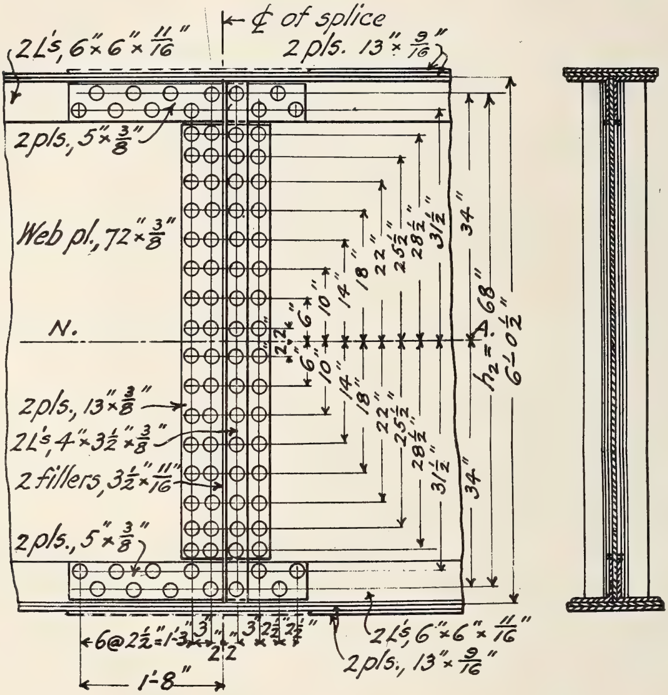

Fig. 3

Since, in general, it is not possible to locate a web splice where there is an excess of flange area, the splice will be designed to develop the full bending value of the web. In the present instance it would be permissible to splice the web for only a part of its bending value if the outer cover plates which theoretically terminate about a foot to the right of the joint were carried past that point, as shown dotted in the figure. By this device no excess material is utilized, however, but the flange is reinforced to relieve the web of part of the bending stress. The same results are attainable in a preferable way, by reinforcing the vertical legs of the flange angles. In the problem under discussion the full resisting moment of the web is equal to one-eighth its gross area multiplied by the permissible fibre stress and by the effective depth of the girder which will be assumed as the depth of the web. This gives $\frac{1}{8} \times (72 \times \frac{3}{8}) \times 16{,}000 \times 72$ 3,880,000 in.-pds.

The vertical shear at the section, which is readily found to be 90,000 pds., must also be transferred across the joint simultaneously with the bending moment. It will be shown, however, that if the splice is capable of withstanding the bending stresses it can resist the shear at the same time without revision of the design.

The most ready method of proportioning the splice is to assume the size of the two vertical splice plates and the arrangement of rivets in them, and then having calculated the resisting moment of these rivets, it becomes an easy matter to ascertain the number of rivets needed in the horizontal splice plates on the flange angles to develop the remainder of the required resisting moment. In the case at hand, the two vertical splice plates will each be assumed as 13″ × ⅜″ and the vertical spacing of the rivets will be chosen as 4 inches with a few shorter spaces at the ends. The net section of the plates should in all cases be capable of developing the same resisting moment as the rivets connecting them to the web, but this will be realized for ordinary cases if the two plates have a total thickness of about twice the thickness of the web and the calculation generally need not be made.

The resisting moment of the rivets in the vertical splice plates on one side of the splice may, from what has already been said, be set down as $\frac{r}{\frac{1}{2} h_2} \Sigma \, y^2$ where

r = least value of one rivet,
h_2 = distance apart of outside gauge lines in the flange angles,
y = distance of any rivet from neutral axis.

The least value of one ⅞-inch rivet will be its bearing on the ⅜-inch web plate, or $\frac{7}{8} \times \frac{3}{8} \times 22{,}000 = 7{,}220$ pds., and $h_2 = 68$ inches. The resisting moment which these rivets can safely develop is therefore

$$= \frac{7220}{34} \times 4 \left\{ (2)^2 + (6)^2 + (10)^2 + \ldots . + (28.5)^2 \right\}$$
$$= 212 \div 10426 = 2{,}210{,}300 \text{ in.-pds.}$$

The difference between this and the total resisting moment of the web, or 1,677,700 in.-pds. must be made up by the rivets in the horizontal splice plates. The permissible stress on a rivet at one inch from the neutral axis due to beding being 212 pds., as determined above, the resisting moment developed by a rivet on the inner and outer gauge lines of the flange angles will be $212 \times (31.5)^2$ and 212×34^2, respectively. Assuming that m rivets are required on the inner gauge line and n on the outer one, we may then equate the resisting moment of these rivets to the balance of resisting moment left undeveloped by the rivets in the vertical splice plates, or

$$2\,m \times 212 \times (31.5)^2 + 2\,n \times 212 \times (34)^2 = 1{,}677{,}700.$$

Solving by trial it is found that m and n in whole numbers must each be equal to 2, these rivets being momentarily regarded as wholly available for the web splice.

The effect of the shear at the splice will now be investigated. Due to bending, the rivets in the outside gauge line of each pair of flange angles will be the ones most severely stressed. At the same time these rivets must resist their share of the vertical shear of 90,000 pds. which is assumed as uniformly distributed over all the rivets in the two vertical gauge lines on one side of the splice, in this case 36 rivets. The test of the sufficiency of the splice is therefore the determination whether the rivets most remote from the neutral axis are capable of withstanding the total stress, from both causes, brought to bear upon them. Since slightly less than two rivets were required in each gauge line of the horizontal splice plates for the development of resisting moment, if two are provided in each gauge line, the stress on the outer rivets need not be as much as the full value of the rivet, but the same proportion of it as the required resisting moment of the splice is to the provided resisting moment. The latter is made up of the resisting moment of the rivets in the vertical splice plates which equals 2,210,300 in.-pds. and the resisting moment of the four rivets in the horizontal splice plates which equals $4 \times 212 \times (31.5)^2 + 4 \times 212 \times (34)^2 = 1{,}821{,}700$ in.-pds. The total provided resisting moment therefore equals 4,032,000 in.-pds., assuming the extreme rivets to be stressed up to their full capacity due to bending alone, and hence the necessary stress on these rivets to develop the required resisting moment is $7220 \times \dfrac{3{,}888{,}000}{4{,}032{,}000} = 6950$ pds. Combining with this horizontal stress the vertical stress due to shear which is $90{,}000 \div 36 = 2500$ pds., we have a resultant stress of $\sqrt{(6950)^2 + (2500)^2} = 7390$ pds. on any one of the extreme rivets, or an excess of 2.4 per cent. over the permissible stress on a rivet according to the assumed rivet specification. This increase in stress is scarcely large enough to make the addition of another rivet necessary, and the case chosen is fairly representative of the most of web splices. It can generally be said, therefore, that if the splice is designed to provide for bending it will resist the corresponding shear without modification. The only case where revision might be necessary would be where the splice comes near the end of the girder, where it may have to be designed for maximum shear with the corresponding moment.

Whether the horizontal splice plates on the vertical legs of the flange angles are regarded as web splice-plates or as reinforcements of the flange, they must have sufficient net area to develop the same resisting moment as the rivets in them, it being assumed for the present that all these rivets are wholly available for the purposes of the splice. This resisting moment has been found to be 1,821,700 in.-pds., and the net area of the two plates multiplied by the permissible fibre stress in them and by the distance between a line midway between the two gauge lines in one flange to the corresponding line in the other flange should be equal or greater than this resisting moment. The permissible fibre stress in these plates will be the permissible stress at their centres or $16000 \times \frac{32.75}{36} = 14{,}550$ pds. per sq. in., and the net area of two plates will be $1{,}821{,}700 \div 14{,}550 \times 65.5 = 1.91$ sq. ins. Two 5″ × ⅜″ plates will be used giving a net area of 3.00 sq. ins.

The length of these plates must be chosen so that the rivets in them on the side of the splice nearest the support will be enough to satisfy the requirements of the web splice and at the same time transfer to the flanges the increment of flange stress which is developed between the last rivet in the plates and the centre of the joint. The result is best arrived at by trial. Assume four extra rivets in the end of these plates, the last rivet coming 20 inches from the centre of the splice. At the splice the spacing for purely flange purposes must be 5.52 ins. in the top flange and the same will be adopted for the bottom. Hence in 20 inches, $20 \div 5.52 = 3.6$ rivets are needed to transfer the increment of flange stress from the web to the flanges. The four extra rivets will be enough for this purpose and the four already provided are required for the web splice. The slight excess of 0.4 of a rivet will be required, since the rivet spacing for flange purposes near the end of the horizontal splice plates should be less than 5.52 inches.

On the other side of the splice only enough rivets are required to develop the net strength of the plates, the least value of the rivets being their double shearing value. This is the case since the most direct route for the stress in these plates to follow is from the plates directly into the flange angles and not into the web and then back into the flange angles. The net area of the two plates being 3.0 sq. ins., and the value of a ⅞-inch rivet in double shear being 13,220 pds., 3.6 rivets are required. Four rivets will be used. The increment of flange stress required to be transferred from the web to the flanges in the distance from the centre of the splice to the end rivet in these plates will not increase the number of rivets, since in considering the two effects simultaneously the least value of a rivet becomes very large—its bearing value on the two flange angles which are together 1⅜ inches thick.

INSULATION TESTING.

E. M. WOOD, B.A.Sc.

Tests on insulation are usually made for one of two purposes—to determine the insulating value of various sorts of materials. or to find out if the insulation of some particular piece of electrical apparatus is sufficient to justify its being put into use, or continued in use. Tests for the first purpose are almost exclusively confined to samples of insulation, and are made in the research or testing laboratories of manufacturing concerns. Tests of the second sort should be made on every piece of electrical apparatus before it leaves the factory, and may, with advantage, be made from time to time on the apparatus as it continues in use. It is with tests of this latter sort that this article will deal.

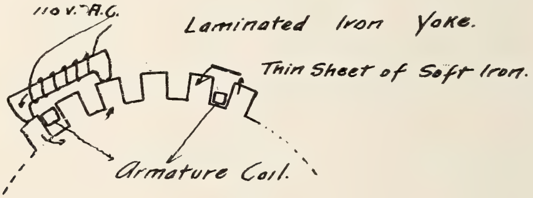

Fig. 1 — Device for locating Short Circuits in Armature Windings.

There are two classes of insulation used in electrical apparatus; first, the "minor" insulation, separating the turns and layers of the winding from each other, and, secondly, the "major" insulation, which separates the winding as a whole from other windings and from the supporting frame or case.

The insulation between turns may be tested by generating in the windings a voltage greater than their normal working voltage. This may be done in the transformer by applying twice normal voltage for one minute, or three times normal voltage for fifteen seconds to some section of the windings, thus inducing the same proportion of voltage in other windings on the same core. The applied voltage should be at as high frequency as possible to keep down "exciting" current.

For a generator, the over-voltage may be obtained by driving it above normal speed, on open circuit, with all the excitation possible. One and a half times normal voltage will be about the maximum obtainable by this method.

There are various methods of testing the wound armatures of generators and motors for short circuits between turns. One typical method is indicated in Figure I:

The portable laminated yoke shown is excited by current at 110 volts, *A. C.* The magnetic circuit is closed through the iron of the armature to be tested, so that the alternating flux surrounds one or more slots with their conductors. This sets up an *E.M.F.* in the conductors, and if there is a short circuit in the coil, heavy local currents in that coil are set up. The presence of these currents can be detected by the flux set up around the other leg of the coil in another slot, use being made of a piece of soft iron to detect the presence of this flux. In the case of a closed winding there will be current and flux anyway, but the presence of the flux is much more noticeable if there is a short circuited coil.

The most important insulation test is the test for the strength of the "major" insulation. This is practically always applied from a testing transformer. The voltage to be applied depends on the rated voltage of the piece of apparatus and the use to which it is to be put. The following table is taken from the Standardization Rules of the A. I. E. E., sections 220-226:

Rated terminal voltage of circuit.	Rated output	Testing voltage.
Up to 400 volts	Under 10 *K.W.*	1,000
" "	10 *K.W.* and over	1,500
Over 400 and less than 800	Under 10 *K.W.*	1,500
" " "	10 *K.W.* and over	2,000
Over 800 and less than 1,200	Any	3,500
Over 1,200 and less than 2,500	"	3,500
2,500 and over	"	Twice rated voltage

There are certain special exceptions noted. Transformers with primary pressures, 550-5,000 volts, whose secondaries are to be directly connected to consumption circuits should have a testing voltage of 10,000, to be applied between primary and secondary windings and between primary winding and core.

Field windings of synchronous machinery to be started by *A. C.*, with fields not excited, should be tested at 5,000 volts.

The above voltages should be applied to the machine at the temperature attained in continuous operation. However, the above voltages should be applied to new machines only, or to machines newly insulated. For old insulation the test voltage should be lower, say from 50% to 75% than given in the table, depending on the condition of the machine.

Practically all electrical apparatus exhibits under high potential test more or less electrostatic capacity. The windings and the iron act as the two plates of a condenser, with the insulation as the dielectric. This capacity requires charging current of the value, $I = C\ w\ E$ where E is the test voltage, C the capacity in farads, and w the frequency in radians per second. The capacity of the testing transformer should be such that it can supply to the test, the above current without instability of voltage ratio and without undue heating of its windings. Mr. C. E. Skinner, in an article on "Testing of Insulation," in the *Electric Journal.* Vol. II., page 538, gives the following table of suitable capacities for various kilovolt ratings:

E. M. F. Kilovolts	2	6	10	30	50	100	250.
Rating K. W.	1	3	5	30	50	100	250.

Since the tendency of an alternating voltage to break down insulation depends on its maximum instantaneous value, and since all *A.C.* voltage measuring devices indicate the square root of the mean of the squares of the instantaneous values, it is evident that for the same voltmeter indication *A.C.* waves of different shapes have different power to puncture insulation. Therefore tests, to be consistent, should be made with *A.C.* waves of standard form, namely sine wave form. The testing apparatus should be of such a nature as to produce, under conditions of test, a voltage wave form as nearly sinusoidal as possible. All tables of testing voltages, and all guarantees of insulation strength assume that the tests shall be made with *A.C.* waves of such form.

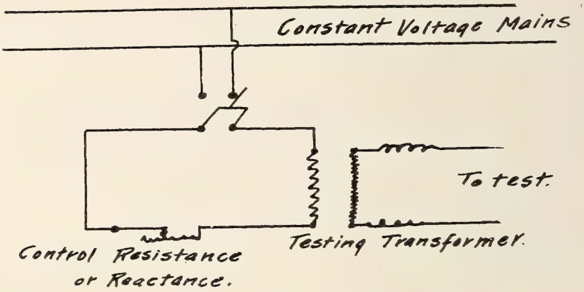

Fig 2. —Testing Set with Resistance or Reactance Control.

The severity of the test for a given voltage depends to a certain extent on the frequency, it being generally true that the higher frequencies give the more severe tests. Tests should then be made at some standard frequency, say 60 cycles, or better, at the frequency of the circuit on which the apparatus is to be used.

The test method of application of the testing voltage depends on conditions. Five of the more useful methods will be outlined.

1. By direct application from a constant potential circuit. This method may be used in all cases up to, say 2000 volts, and in case of switches, insulators, etc., which have little electrostatic capacity, for any voltages.

2. Voltage from constant potential circuit with testing transformer. Control of voltage is obtained by means of a resistance or reactance in the primary circuit as shown in Figure 2.

A water rheostat, or a variable reactance, for example a "theatre dinimer," makes a suitable form of control. The reactance has the advantage of consuming less power, and of giving steadier control, as the water resistance is liable to fluctuate, due to the formation of gas on the plates. The method is useful for voltages up to 25,000. It has the disadvantage that the controlling resistance or reactance necessarily distorts the wave form of voltage. This is not of vital importance in tests up to 25,000 volts, but eliminates the usefulness of the method for higher voltages.

3. Voltage from generator with testing transformer, control is obtained by variation of generator field. Connections are as shown in Figure 3.

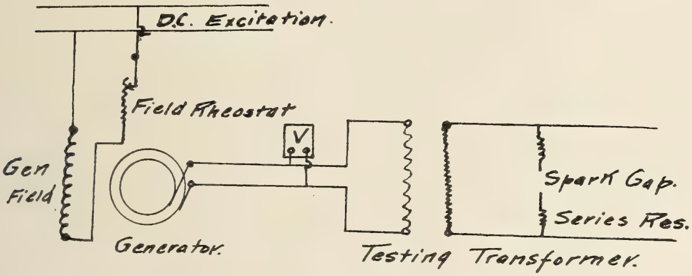

Fig. 3— Insulation Testing Set with Generator Field Control.

The method is available for any voltage and any capacity. It has the disadvantage that it requires a special generator as part of the testing set. The method gives best results when the generator is worked at approximately normal voltage, practical limits of allowable variation being from 50% to 125% normal voltage. If these limits are exceeded the wave form is liable to be distorted by the load, and especially at low excitations the voltage will be unsteady if the transformer is loaded with "leading" current, as is the case in tests on high tension power transformers, cables and all apparatus with high electrostatic capacity between windings and frame. This method or the previous one is highly satisfactory for all high potential tests on other classes of electrical machinery. For testing apparatus like high voltage transformers and cables, one of the following methods is preferable.

4. From a constant potential circuit with a testing transformer, with voltage control by auxiliary transformers whose sections are cut in or out by dial switches. Various forms are in use, one of the best of which is shown diagrammatically in Figure 4.

This uses two regulating transformers besides the testing transformer. The voltage variation is in steps of one-quarter of one per cent. from zero voltage to full rated voltage, each of the regulating transformers being in 20 sections. The variation from step to step is made without opening the primary circuit, a very important advantage, especially in tests at high voltages. In case of break down the circuit breaker C.B., opens and allows the current to pass through the choke coil, permitting the fault to be burned out if desirable.

The voltage supply is usually from some generator which gives a proper wave form. This generator may supply power for more than one testing set if required. It may be convenient to make the testing set portable, and to bring out terminals from the supply generator at proper places throughout the factory, so that the set can be rapidly connected to any set of terminals.

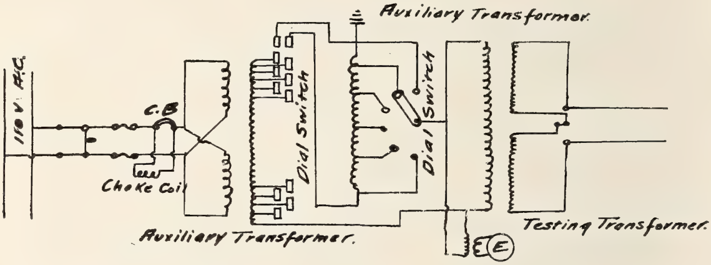

Fig. 4 – Testing Set with control by Auxiliary Transformers.

The above method is a perfectly satisfactory one for all conditions of high voltage testing.

5. Voltage from constant potential circuit with transformer, controlled by means of a single phase induction potential regulator in its primary circuit, as shown in Figure 5.

The regulator must be of special design, with the same voltage in secondary as in primary, or in other words, with a "buck" or "boost" of 100% of the line voltage. Then when working on 500 volt circuit, with primary in maximum lowering position, the voltage at the transformer primary terminals will be 500—500=0 volts. The voltage can be raised gradually, by turning the hand wheel, until the primary is in maximum "boost" position when the voltage at the primary of the testing transformer is 500 + 500 = 1000 volts. The worm-gear and wheel should be cut with a compound thread so as to give a very gradual variation of voltage. The regulator should work "snugly," so that there is no "play" in the movable parts, but should not be so tight that it cannot be turned steadily by hand.

This method is quite satisfactory for all kinds of insulation testing. It has one advantage in that the experienced operator can judge by the way in which the "wheel" turns, approximately what is happening in the apparatus under test.

It is, of course, of great importance to be able to measure with some degree of accuracy, the voltage applied in the test. There are at present no entirely satisfactory methods, though there are several in use.

1. By ratio of transformation, with voltmeter on low tension side of testing transformer. This method neglects "regulation" and is only useful where accuracy is not important, that is in tests up to 10,000 volts.

2. By special "voltmeter coil" of known number of turns on the core of the testing transformer. This is more accurate than the first, for it eliminates that part of the regulation due to the primary.

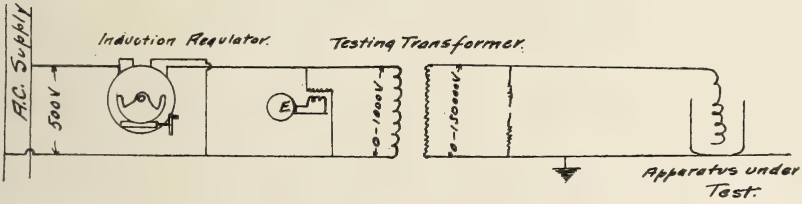

Fig. 5 - Insulation Testing Set with control by Induction Regulator.

3. By special "voltmeter coil, this being part of the high tension winding. This is theoretically an improvement on 2, but it must be taken off next to grounded terminal of the winding, and unless this is the middle of the winding these turns are liable to be not representative of the rest of the winding, on account of leakage fluxes, etc.

4. By voltmeter in the high tension circuit. This is the ideal method, but unfortunately it has serious practical limitations. The use of series resistance of potential transformer, with a voltmeter for 20,000 volts or over, would be too expensive and consume too much power for commercial use for measurement of test voltages. The static voltmeter, if there is a reliable one on the market, would be the best method available for the measurement of high voltages.

5. By spark gap in the high tension circuit. This method is the one most frequently used. It is not absolutely reliable, but with care yields fair results. The Standardization Rules of the A.I.E.E. state with regard to the use of the spark gap (Sec-

tion 245): "The spark points should consist of new sewing needles supported axically at the ends of lineas conductors, which are each at least twice the length of the gap. There should be no extraneous body near the gap within a radius of twice its length."

To prevent a large rush of current and consequently high voltage surges when the gap breaks, there should be inserted in series with each of its terminals, a resistance of one-half ohm per volt. These resistances may be carbon resistance rods, similar to those used in lightning arresters. These resistances usually decrease the gap setting for a given voltage by an amount which should be determined experimentally (about 5%).

Moderately low voltage tests, say up to 30,000 volts, require no particular care in application, except that they should be isolated so that no one will get hurt, and that the application of voltage should be fairly smooth. Voltages over 10,000 should be checked by spark gap in high tension circuit.

Voltages, 30,000 to 80,000, require more care in applying the voltage smoothly and removing it smoothly, that is, without sudden vibrations. The spark gap should be set for the required testing voltage, with the apparatus to be tested connected in as shown in Figure 5, and the voltage raised until the gap arcs over. Just *before* the break, a voltmeter reading should be taken. As soon as the gap breaks, the voltage should be lowered to zero and the gap opened say 10 % beyond the setting for the required voltage. Then voltage should be applied again with the same voltmeter reading, and held one minute, then lowered to zero. A break is indicated by the drop of the voltmeter needle to zero, and by the action of the apparatus, as burning usually follows a break-down.

At voltages higher than 80,000, with apparatus of high electrostatic capacity, it is dangerous to break the gap at full test voltage, for the arcing gap sets up voltage surges of the worst sort. The difficulty may be obviated as follows: The gap may be set at two-thirds the required voltage, and broken, with the transformer in circuit, the primary voltage being read just before the break. The voltage should be reduced to zero, and the gap opened to 10% above the distance for required testing voltage. The voltage should be then applied till the voltmeter reading is three-halves its former value, held for one minute and lowered gradually to zero. This method is sometimes satisfactory and sometimes not satisfactory. Variations are suggested by experience to fit the various conditions that arise with the different sorts of apparatus that are to be tested.

There is another insulation test, the measurement of "Insulation Resistance." This may be done roughly by a well-known high resistance voltmeter method, or by direct reading megohmmeter. It is chiefly of value in determining the state of the insulation with regard to moisture, since the greater the degree of moisture, the lower the insulation resistance. Any piece of apparatus that shows low insulation resistance (below one megohm) should be carefully dried out before an application of high potential is made.

This article will conclude with a few general practical suggestions on making the insulation tests.

1. Since the voltages used in insulation testing are all dangerous to life, too great care cannot be taken to prevent any person coming in contact with the live circuits.

2. When a machine has more than one winding, all windings except the one under test should be carefully connected to the frame, which should preferably be grounded. This is to prevent undue electrostatic stresses being induced, tending to break down the insulation from these windings to ground.

3 If there is more than one accessible point in any winding to be tested, all accessible parts should be carefully connected together electrically. This is to insure uniform application of voltage to all parts of the winding, and is a very important point. It often makes the difference for a piece of apparatus between standing the test, and failing.

4. Application of voltage should be gradual, without sudden variations but not too slow, as the severity of the test depends on its duration. For a test of 160,000 volts to a large transformer, it would be a good rule to take one minute to raise the voltage from 0 to 160,000 volts, hold at that value for one minute, and take one minute to lower the voltage to zero. No apparent impending breakdown should induce the operator to make a sudden reduction in testing voltage, for if he does, the break will become a certainty.

5. Any means possible of reducing the static discharge in a high tension test, is of advantage for the static discharges are liable to set up surges which may cause break down of insulation.

6. All connections should be made tightly and with good contact.

SOME RECENT ADVANCES IN ELECTRO-CHEMISTRY AND ELECTRO-METALLURGY.

SAUL DUSHMAN

The application of electrical energy to the performing of a large number of reactions previously carried out by purely chemical methods, has at the present time attained to a position of great commercial importance. This has been due largely to the rapid developments that have taken place in methods of power production. So long as the cost of electric power was high, the idea of supplanting ordinary chemical or metallurgical processes by the more simple electro-chemical ones could not be entertained, and electro-chemistry remained practically a laboratory science. But it was during this period that the foundations were laid for many of the most important electro-chemical industries of the present time, and, as a result, the advent of cheaper electric power found the electro-chemist prepared to utilize the advantage which was thus held out, and during the last decade the progress in electro-chemistry has been so enormous that in very many cases the electric power plant has been installed on account of the electro-chemical consumers.

Some of the electro-chemical industries, such as the carbide, carborundum, aluminium, copper-refining and caustic soda processes, have long since passed beyond the experimental stage, and their products have become vital necessities in the industrial world. Other processes, however, have obtained a great deal of prominence in the last few years, which cannot be said to be as yet in a state of assured stability, and these, since they are probably not so familiar to many of our readers, form the subject of the present article.

It is a long step from the time of Cavendish to the present, but the relatively unimportant fact discovered about the year 1776, that an electric spark passed through a moist mixture of oxygen and nitrogen will produce nitric acid, is the basis of a large number of projects, that have recently become technically important, for the fixation of atmospheric nitrogen. As is well known, our wheat crops require for their successful growth, a certain amount of fertilizer to be supplied to the soil. Nitre, or Chili saltpeter has been the substance chiefly used for this purpose in the past; but the beds of nitre in Chili are gradually becoming exhausted, and even if the supply be available for a much longer period than Crooks averred in 1892, the world has come to realize that some other source of fertilizers must be sought for, if its food supply is to remain assured. The essential requirement of a fertilizer is that it shall contain nitrogen, in a form which can readily be absorbed by plants; this condition is fulfilled very well by nitrates. Now all around us, constituting the very atmosphere we breathe are present the essential components of nitric acid, and it is therefore not surprising that the old experiment of Cavendish has again been brought to light and the question has arisen, how the fixation of atmospheric nitrogen may be performed on a commercial scale?

Lack of space will not permit us to review the preliminary work of different experimenters in Germany and England who, during the years 1897 to 1904, sought to solve the problem. Their experiments, although they did not result successfully from a commercial point of view, led to the conclusion that the main reaction in the electric arc is the formation of nitric oxide according to the equation,

$$N_2 + O_2 \rightleftarrows 2NO,$$

the amount of NO increasing with the temperature and depending at constant temperature on the concentrations of the components, according to the Mass Law. It was also shown by Nernst* that the proportion of air converted into nitric oxide is always very small, and even at 2600° *C*, it amounts to only two per cent. by volume.

These investigations thus prepared the way for the first commercial process, that devised by Birkeland and Eyde in 1904. They use a 5,000 volt alternating current arc between water-cooled copper electrodes, and by means of a magnetic field at right angles to the latter, the arc is spread out into a disc over 2 metres in diameter, thus causing almost the whole volume of air in the furnace to be raised instantaneously to a very high temperature. Owing to the circulation of air through the furnace, the nitric oxide formed there is cooled before it has a chance to dissociate, and combines, at 600° *C*, with oxygen to form the higher oxide, NO_2. This is passed through a series of towers washed with water and gives a 50 per cent. nitric acid, which is then saturated with lime and converted into a basic nitrate useful as a fertilizer. The furnaces used by Birkeland and Eyde are each of 500 kilo-watt capacity, and while in their original plant at Notodden, Norway, only 1,500 kilo-watts were used, this has since been increased to 40,000 *KW*. The yield is 70-83 grams pure nitric acid per kilo-watt hour, which corresponds to 500-600 kilograms per *KW* year, and the inventors claim that this figure can be considerably increased.** It may, however, be stated in this connection that the main reason for the success of this process is the fact that power in Norway can be obtained at the extremely low price of approximately $5.00 per *HP* year, a figure which is probably much lower than that quoted in other countries.

Simultaneously with the Birkeland-Eyde process there has been developed another one by the Badische Anilin and Soda Fabrik. "They employ an arc in a long tube through which air is passed in a whirling motion. Since 1907 they have operated

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*Nerust, *Zeit. f.* **Elektrochem.** 12, 527.

**Erlwein, Elektrotech Zeit, Jan., 1907.
Edstrom, Trans. Am. Electrochem, Soc., 1904.

an experimental plant of 2,000 *HP*, and are now planning the erection of a large 120,000 *HP* plant."*

The problem of the fixation of atmospheric nitrogen has also been solved in a totally different manner. A few years ago the search for a commercial method of producing cyanide of potassium led Drs. Frank and Caro to the discovery that when nitrogen is passed over calcium carbide at a high temperature, such as that of the electric furnace, there is produced a compound having the formula $Ca\ CN_2$ and known as cyanamide. This substance is capable of yielding a large number of interesting derivations by treatment with suitable reagents; ** thus by melting with certain fluxes it yields potassium and sodium cyanides; by the action of steam it gives off ammonia which may be converted into ammonium sulphate, and it has also found application in the organic dye industry as well as in the tempering and hardening of steel. But its most important use has been found to be as a fertilizer. Investigations by Dr. Hall at Rothamstead have shown that as a manure it is equal to nitre or any of the artificial fertilizers. It is, morever, cheaper than the basic nitrate produced by Birkeland and Eyde. According to Dr. Frank, "to replace the present consumption of Chili nitrate by cyanamide would require something like 800,000 *HP*, and works are springing up all over the world to produce it wherever water-power is abundant and cheap."*** The original works of Frank and Caro at Piano d'Orte, in Italy, are being extended at the present time to an output of 10,000 tons and numerous plants are installed or being contemplated in various European countries as well as in America. The United States Cyanamide Company is erecting a 5,000 to 6,000 tons works, at Niagara Falls, Ontario, and will shortly build another installation in Tennessee.

While important progress has thus been made in processes for the utilization of atmospheric nitrogen, electrical methods have also been invading a field in which at first there seemed to be little probability of their gaining a foothold. But the cheap, efficient manner in which electrical energy can be applied instead of coal in many branches of the iron and steel industry has caused the new methods to become an important factor even here. During the latter part of the nineteenth century immense strides had been made in both the theory and practice of iron smelting. The conditions governing the nature of the product obtained in the blast-furnaces were investigated thoroughly; so that the iron metallurgist could produce an iron of any desired quality. Similar progress had been made in the manufacture of steel. But the scarcity of coal in many places where both ore and cheap power are available caused many persons to consider the advisability of using electricity to do the work ordinarily performed by coal. The report of the Canadian Commission has been long enough before the public for all to become fairly familiar with its contents, and a great many Canadians have come to realize the immense possibilities of electro-thermic processes in this country. However, the time seems hardly ripe for an extensive development of electrical iron smelting, and we cannot do better than quote, in this connection, the opinion of Mr. J. Harden, a noted metallurgist.* After comparing the two processes for reduction of iron ore, he concludes that "where conditions are the same in both cases, as to the class of ore, amount of labor, and class of fuel available, the electric smelting furnace requires an expenditure of $9.70 per ton of produced iron, while the blast furnace requires only $6.84 or $2.86 less per ton of iron." He then reviews the difficulties which have occurred in the various types of electric furnaces, and makes the following noteworthy remarks:—

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*Electrochem, Ind. VI, 478, Dec., 1908.

**Erlwein, Elektrotech. Zeit, Jan., 1907; also Chem. Ind., 1907.

***Report of a lecture to the Faraday Society, Electrochem, Ind., VI, 341, Aug., 1908.

"It is certainly not our intention to stamp the electric smelting furnace as a hopeless impossibility—far from it; but it is only intended to state things as they are at the present, and keep some of those optimists a little nearer the earth who dream that the days of the good old blast furnace are doomed, and must give way to the more modern electric smelting. We certainly believe that the smelting furnace is capable of attaining perfection, like everything new, but all improvements must go steadily forward, not in leaps and bounds, as the effects of undue rashness are only leading us astray." His conclusion is that electric smelting would be justifiable only in such regions as India or Western States of U.S.A., where there is practically no coke, while there are large deposits of cheap ores and abundant water-power. The carbon required for the chemical reduction could be obtained by converting wood and forest waste (which may be had there in large quantities) into charcoal.

While the success of electric smelting is thus still a probability, the production of steel in the electric furnace has become an established process. The first steps in this direction were made by the carbide and aluminium producers at a time when an over-production of these products on the European market threatened many electro-chemical installations with absolute ruin. Naturally, the products initially turned out were more or less novelties, like the ferro-alloys. A gradual education of the steel consumers has, however, not only led to a greatly increasing demand for such special alloys, but has also encouraged the electro-chemical manufacturers to enter upon the production and refining of steel. Here the electrical processes possess undoubtedly superior advantages, both from the point of view of efficiency and of ability in controlling the quality of product; and when Mr. Chas. M. Schwab** states that in his opinion the near future will see the electric steel furnace an essential part of all existing steel plants, it is evident that the advantageous results to be obtained by using the new process have been perceived by the most important steel producers.

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*Electrochem. Ind. VII, p. 16, Jan., 1909.

**Report of Mr. Schwab's testimony before the Ways and Means Committee in the recent tariff hearings, as given in Iron Age, 1908.

Out of the large number of new developments that have occurred in this industry within the last couple of years, two are especially worth noticing. One of these is the Lash steel process, the object of which is to make any desired steel by properly mixing ore, cast iron and carbon and then subjecting the mixture to heat. "The essential features in the process seem to be the fine state of division of the constituents of the mixture, their intimate association, and the use of iron containing metalloids in considerable quantities."*

The other great development has been the Roechling-Rodenhauser modified induction furnace. The ordinary induction furnace is in reality a transformer in which the secondary is constituted by a ring of molten metal. Owing to the high temperature of the latter, careful heat insulation has been found necessary from both the primary and magnetic iron core. The result has been a considerable magnetic stray flux and consequently a low power-factor. Attempts have been made to reduce this defect by lowering the frequency of the alternating current generators, and frequencies as low as 15 have been used. But the most recent innovation due to Messrs. H. Roechling and Rodenhauser of the Roechling iron and steel works in Voelkingen, Germany,** consists in having an additional secondary coil connected with metal plates which are separated from the molten bath by a refractory electrolytic conductor of the same kind as used in the Nernst lamp, so that the metal is heated not only by induction currents but also by currents passing through it between the electrode plates. Single-phase current was originally used in this furnace, but more recently three-phase current has been used successfully,*** and it has been found possible to operate such furnaces economically with alternating current of ordinary frequency, so that the necessity of building special and expensive generators is thereby obviated. The principal use for this type of furnace is in further refining the steel after it is blown in the converter, the additional cost of electric refining being more than compensated by the greater density and homogeneity of the product. It is also interesting news that by this method more than 1,000 tons of steel rails have been made and sold by the above iron works to German railroads.

Not only in the electro-metallurgy of iron and steel but also in other fields of electro-chemistry there have been many signal advances. Acheson's deflocculated graphite and Potter's "Monox" form the latest additions to the already large number of electric furnace products. The former of these is the result of Mr. Acheson's discovery that fine, pure graphite (which he succeeded in producing during 1906) when digested with water containing a trace of tannin becomes capable of remaining suspended in the water for an indefinitely long time, forming as it were a colloidal solution. In this condition, the graphite is designated by its inventor as "deflocculated," and the aqueous suspension has the singular property of being an excellent lubricant. When added to oil, deflocculated graphite reduces its coefficient of friction considerably. It therefore seems as if it will obtain important commercial application.

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*Electrochem, Ind. VI, 493, Dec., 1908.

**Stahl u. Eisen, Nov. 6, 1907.
Electrochen, Ind. VI, p. 10, Jan., 1908.

***Electrochem, Ind. VI, p. 457, Nov., 1908.

Dr. Henry Noel Potter has obtained silicon monoxide by reducing silica at the temperature of the electric arc either by silicon or coke.[*] The temperature thus produced which has the formula SiO (analogous to CO), has been called "monox" by its inventor. In the air, it burns very readily to silica and this explains why it has not been obtained under the conditions existing in the carborundum furnace. In the furnace designed by Dr. Potter a mixture of sand and coke, or carborundum fire sand, is subjected to the action of an electric arc between two horizontal electrodes which are covered by the charge. As soon as the reaction begins, the monox vapor produced blows a funnel-shaped hole through the charge and is then chilled by contact with the walls of a large enclosed drum which covers the top of the charge. As this drum is practically free from air, the vapor does not burn but is condensed as a deposit on the walls of the container. The solid monox is a fine, opaque, light-brown powder which possesses many interesting properties. It has been found to be a valuable pigment in certain oil paints, in particular paints for brick-work and paints for protecting structural iron from rusting. It is also a good addition to black printing inks; and the probabilities are that many other uses will be found for it.

This completes our brief survey of some of the recent advances in electro-chemistry and electro-metallurgy. A great many things have necessarily been omitted; such as the work done by Edison and others on the iron-nickel accumlator; the electrolytic refining of lead, silver, and gold; the production of caustic soda and chlorine in the Townsend cell; the aluminium rectifier, and numerous other topics. But perhaps even the above few remarks may serve to show that not only has the development of electro-chemistry in recent years taken place in many directions that even the most imaginative scientists of twenty years ago did not foresee, but also the future will probably see more and more of the ordinary chemical and metallurgical operations replaced by electro-chemical processes. Especially will this be so for our own province, where, as well known, hydro-electric power is readily available, and there is an abundance of the choicest raw materials.

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[*] Trans. Am. Electrochem Soc. 12, 1907, p 217,

FERTILIZERS AND THEIR MANUFACTURE*

F. K. HARRIS, '09

The object of a fertilizer is to supply to the soil those elements and constituents which the plants have absorbed in the process of their growth, and, generally speaking, there are three primary elements which need to be supplied, namely:

(1) Ammonia or nitrogen.

(2) Phosphate of bone containing about 50 per cent. free phosphoric acid.

(3) Sulphate or muriate of potash, sulphate being the best.

These three ingredients mixed with pure sand and water will stimulate the growth of vegetation, and as the sand has not the elements that will sustain plant life the test shows that the added fertilizer supplies the necessary food.

A rich land has all the elements to a greater or lesser degree, while a poor land lacks some, or nearly all, and some land will have all the elements but one. But no matter how rich the land is an addition of fertilizer generally proves a benefit, increasing the yield with the same labor. There are two general classes of fertilizers:

(1) Indirect fertilizers.

(2) Direct fertilizers.

An indirect fertilizer is one which does not in itself furnish directly to the soil any needed plant food, but whose chief value depends upon the power it has of exchanging unavailable into available forms of plant food. Those which are employed most commonly are lime, gypsum and common salt.

Gypsum, known also as calcium sulphate, or sulphate of lime, in some manner aids the process of nitrification, by which the ammonia and the nitrogen of organic matter are converted into nitric acid and nitrates. It also acts on the insoluble forms of potash and other elements of plant food, converting them into soluble and available forms. It is of value to such plants as clover and peas, etc.

Quick lime, or burnt lime, or calcium oxide, commonly called lime, change both the physical and the chemical character of soils. Freshly burned lime acts by decomposing vegetable and mineral matter already present in soil and changing them into forms which are available as food for the plant. Thus lime acts upon insoluble mineral substances containing potash and converts them into soluble forms. Lime aids in decomposition of animal and vegetable matter, such as vegetable mold, stable manure, etc., and tends to convert them into available plant food. Lime should be used along with other fertilizers.

Common salt has an indirect fertilizing value, which is mainly due to its power of changing unavailable forms of plant food into available, especially potash.

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*Read before the Chemical and Mining Section of Engineering Society, Nov., 1908.

Hence we see if these were used alone the soil would soon become exhausted, and become of no value.

Direct fertilizers contain forms of plant food which contribute directly to the growth and substance of the plants. Such materials may contain either nitrogen or potash, or phosphoric acid compounds, or any two or all three of these forms.

Some of these direct fertilizers are:

Nitrate of soda, known as Chili saltpetre, found in Chili and Peru of S, A., contains 15½ to 16% of nitrogen.

Sulphate of ammonia is formed from waste products produced in manufacture of illuminating gas or coke. This contains about 25% of NH_3, which is equivalent to about 20½% of nitrogen.

Cottonseed meal is product form, after extraction of oil from cottonseed oil. This contains about 7% nitrogen, 3% phosphate and 2% potash.

Tobacco stems are refuse from tobacco factories, and consists of 5-8% potash, 2-3% nitrogen and small quantity of phosphoric acid.

Dried blood consists of blood obtained from slaughtering animals. It is prepared by evaporating, drying and grinding, This contains 10-15% nitrogen.

Dried fish scraps and ground fish are refuse from canneries and contain 7-8% nitrogen, together with as much insoluble phosphoric acid.

Meat scraps and tankage are slaughter-house refuse, dried and ground. Good tankage contains 10% or more of nitrogen and as much phosphoric acid.

Nitrogenous guanos are formed in dry regions. The Peruvian guano contained 7% of nitrogen, 7-12% phosphoric acid and about 1% potash.

Bones.—These consist mostly of calcium phosphate, which consists about 3/5 wt. of the bone. The remaining portion is a soft, flesh-like substance, called gelatine, which is rich in nitrogen. Bones which are used in making commercial fertilizers contain from 4-5% of nitrogen, and 20-25% of phosphoric acid, of which 1/3 is available.

A fertilizer largely used in Southern States at present is known as rock phosphate. The chief rocks which are used are apatite, caprolite and phosphorite. Until recently a large quantity of apatite was exported from Canada to Southern States from around Ottawa district for this purpose. But the discovery of the rocks of this nature having been made in the States the trade in Canada came suddenly nearly to a standstill.

In Southern States phosphate rocks are named by names which designate localities from which they come, as South Carolina rock, Florida rock, etc., and contain as much as 25-30% phosphoric acid. These rocks are in an insoluble condition, and of no use as they are. To make them available they are allowed to weather along with sulphuric acid, 100-lb. rock being treated with about 60 lbs. acid. This weathering takes from 4-6 months, in order that the rock may be thoroughly disintegrated. As much as 64% phosphate has been obtained in this way.

Market fertilizers contain, according to requirements for different plants for which they are used, from 2-8% NH_3, from 6-10% of bone phosphate and 4-10% potash, the balance being a filler, so that when a market product is mixed about these percentages of plant food are used with enough cheap ingredients, such as ashes and dirt, to make required weight and bulk.

Another form of fertilizers which has found its way into the market during this last century is the slag, which is run off from the basic furnaces used in the iron manufacture. These furnaces are lined with basic materials, such as lime, and during the blasting the lime absorbs the phosphorus from the iron forming the calcium phosphate. This forms the slag. It is run off while molten steam is blown through, which makes it porous and light.

This is now ground up and sold under the name of the "Thomas slag." It is very rich in the phosphates, the chief one being calcium phosphate.

This was first used in Germany and it is estimated that 1,000,000 tons are used yearly for this purpose.

An analysis of this slag is approximately as follows:

P_2O_5 - 16 20%
CaO - 40-50
MgO - 2-5
Si - 6
$\left.\begin{array}{l}FeO\\Fe_2O_3\end{array}\right\}$ - 8-15
MnO - 5-11
Al - .5-.6
S - .5

We will now consider the manufacture of tankage fertilizer and bone meal from raw material to the finished product.

The raw material is obtained from packing houses, abbatoirs, slaughter-houses and butcher shops. It consists of the refuse from these places, such as carcasses of dead animals, offal and blood from slaughter-houses, bones and tallows and fats from the butcher shops and bye-products, such as meat scraps, etc., from packing houses. This is hauled either by teams or railroad to rendering works. Here the hides of dead animals are taken off and placed in the tanning room. The carcasses are quartered and placed in large iron tanks, which vary in sizes according to size of plant. The most modern ones are about 5-6 ft. diameter and 20-25 feet long, the capacity of these being about 10 tons.

The different kinds of refuse are placed in different tanks. The butcher bones and cattle heads are placed in one tank, the tallow and fat in another, and likewise the offal in another.

When the day's run is in these tanks, whose lids are screwed down in order to stand pressure without allowing any gas or steam to escape, the contents are cooked. This is done by allowing live steam from the boiler to pass in.

All pipes leading from the tanks being shut off by means of valves a pressure is created in the tank, which is allowed to run up from 15-20 lbs., denoted by means of a steam gauge. Under this pressure the length of time of cooking for different materials varies. A tank of 10 tons capacity, when filled with bones, etc., requires from 10-12 hours, while a tank of same capacity of offal requires about 8 hours.

After the cooking or rendering is completed pressure is allowed to go off. This escaping steam is laden with odors, which, if allowed to escape in air, would create a nuisance, hence a device must be had to do away with this.

Some plants lead their exhaust pipes through coils immersed in water, and from there lead into a cavity dug in the earth, where gases condense. Some lead the gases into a water tower, and there in contact with water some of them condense along with steam, while the remaining gases are drawn by a fan and are used for a draught for fires under boilers, there being burnt and allowed to pass out the chimney.

When pressure has all escaped the lid of tank is raised and the grease and oil are skimmed off. This is done by a pipe which is about ¾ way up the tank. In case the oil is lower than pipe liquor from another tank is pumped into the bottom, thus raising the oil.

After the oil has been taken off the tanks are drained of the liquor they contain. This is run by means of a pipe from the bottom of the tank into another division of the factory, called the wet tankage plant. This is done to each tank. After draining off the liquor from the tanks they are dumped. This is done by means of a slide attached to a wheel. They are dumped into vats. From here the bones from bone tanks go through the process of riddling while the offal and the carcass tank are washed with water, in order to obtain as much grease as possible, and then pressed in the hydraulic press.

The process of riddling which the bones undergo is similar to panning gold. The flesh on the bones after being cooked only slightly adhere to bone, hence may easily be separated. The riddle is a round vessel with a meshed bottom, each mesh being about 1″ square. A man shovels the cooked material into one of these riddles and then washes it under water by shaking. The flesh falls through the riddle and the bones are sent along to the drying room.

After being riddled the meat is then placed in an hydraulic press and pressed under a pressure of 120 lbs. for about 2 hours. This removes excess of water and grease and now the product is known as crude wet tankage. This tankage contains about 50-60% of moisture, and in order to make it into a product which could be shipped in bulk without any fear of decomposition the moisture must be reduced to at least 10%. To do this it is passed through what is called dryers. There are many types and descriptions. One of the oldest consists of a brick work enclosing a boiler. Pressure was kept up in this boiler to about 60 lbs.

The tankage was fed into a worm by a man and shovel. This worm led it to slot where it dropped, and by means of a long shaft fitted with paddles it was made to pass over the boiler. At end of first shaft it was dropped into another slot, where it was carried back by means of a shaft running in the opposite direction. Then it was returned by means of a third shaft and passed out containing from 6-10% moisture. This method was slow and continuous and required two men, one to feed it and one to take it away and keep up steam; hence it incurred a greater expense which the more modern ones do away with.

The more modern ones consist of an cylindrical iron vessel, about 6′ in diameter and about 18-20′ long. This is encased in another cylindrical vessel about 12″ greater in diameter.

The tankage is carried by means of a worm into the inside of the inner encasement until charged. The capacity of this ranges from 1,800 to 2,200 lbs., depending on nature of tankage. When charged the lid is placed on feed box and steam is turned on from the boilers. This steam enters between the two encasements and causes the moisture to evaporate from tankage as it comes in contact with encasement. The exhaust steam is let off. The water vapour from the tankage is carried away and allowed to condense in condensing chamber.

The length of time it takes to dry varies with the various kinds of tankage. If too much grease escapes previous operations it has a tendency to form in balls. This outer portion of ball will dry out and harden, while the inner portion will contain as much as 30% of moisture. This is one reason, other than that of value, why grease should be removed as much as possible.

The time it generally takes to dry is about two hours. When dry it contains about 8-10% moisture and is dumped and shipped as crude tankage to mixers, where it is mixed with potash, etc., as is needed by consumers.

In order that the tankage may be brought in contact with the hot encasement of the dryer the latter is fitted with a shaft runing through the centre. Connected with the shaft are paddles. These paddles revolve and carry with it the tankage. This serves also to prevent the tankage from forming hard lumps as previously stated.

The liquor from the tanks is run over to the wet tankage plant. Here it is allowed to settle in vats or cess pools. Any solid matter carried by the liquor settles to the bottom and any grease that has escaped rises and is skimmed off.

The liquor now is evaporated down to a semi-fluid condition in vacuum pans.

These are generally set up in pairs. The first pan is run at about 13 inches vacuo and the second effect at about 26 inches vacuo.

The vacuum draws the liquor into the pan from the settling vat by means of a pipe. Since the liquor is under vacuum pressure, the temperature required to boil it would be less than if it were boiled under ordinary conditions. Hence the exhaust steam from the engine can be used to do this.

In the first pan it is boiled down to a certain consistency (about that of cylinder oil) and then it is drawn over into pan No. 2. This pan being under greater vacuum will draw it from the first pan, and under this greater vacuum the temperature required to boil it is still less. Thus the vapour which comes off from the first pan is hot enough to evaporate the liquor in the second pan.

In the second pan the liquor is evaporated to the consistency of about 18° Beaumé, and contains 40-50% moisture. This is pumped when hot into barrels, or it may be fed into the dryer with the tankage. It contains a very high percentage of ammonia, and, in mixing it with the tankage, raises the quality of latter and consequently the value.

In some cases this evaporated liquor, or, as it is known commercially as "stick tankage," may be dried to a powder.

This kind of dryer consists in a revolving cylindrical vessel about 12′ feet long and 4′ in diameter. Steam is passed to the inside, and on side of this dryer is a pan containing the semi-fluid. As this dryer revolves it passes through the liquor, which adheres, and as it revolves the temperature of surface is great enough to drive off the moisture and dry the material.

On the opposite side is a knife, which fits closely to the dryer and scrapes off the dried material into a vat, from which it is placed in the storage room.

The fertilizer, as it now is, is sold to the manufacturers of mixed fertilizer and is sold on the basis of analysis. The two constituents which are of value are ammonia and phosphate of lime. The former being about twenty times more valuable than the latter, hence it is sold on so much per unit of ammonia and so much per unit of phosphate.

To make what is known as bone meal fertilizer the bones are cooked under pressure until they become porous and mealy. This takes about two hours longer than the previous operation. These are then treated similarly to the other fertilizer. It contains 20-30% bone phosphate of lime. The amount of phosphate of lime is estimated on amount which the land will absorb.

It was found that the amount absorbed by the land in course of time was equivalent to the amount which would be dissolved in an ammonium citrate solution. This, along with those phosphates which were soluble in water, were called the available phosphoric acid. But when the "Thomas slag" was used it was found that the ammonia citrate would not dissolve any of the phosphate, but that 1% citric acid solution would dissolve an equivalent amount. Therefore, instead of ammonium citrate 1% citric acid solution is used, and available phosphoric acid is the sum of phosphoric acid which is soluble in water and that soluble in a 1% citric acid solution. The nitrogen is estimated as ammonia by the Kjeldall's method. The nitrogen is changed to ammonium sulphate by means of strong H_2SO_4, and the ammonia is driven off by addition of KOH. The ammonia is caught in a known amount of standard acid, and the excess of acid being titrated off, the amount of ammonia can be calculated.

W. HODGSON ELLIS, M.A.M.B.

Dr. Ellis' connection with the School of Practical Science dates from the year 1878, when, on the organization of that institution, he became Assistant to the Professor of Chemistry, Dr. H. H. Croft. Prior to this, he had been a practising physician in this city, but this he gave up in the early seventies on receiving an appointment on the staff of the College of Technology, then located in the Mechanics' Institute building, the present Public Library. This College of Technology was the prototype of the School of Practical Science, now the Faculty of Applied Science and Engineering of the University of Toronto.

No professor of this Univeristy has won the respect and affection of associates and students to a greater degree than has Dr. Ellis. No professor's judgment on matters of academic policy was ever saner and no one's advice has carried more weight than has his. Of ripe scholarship, varied attainments, unexcelled honesty and broad sympathies, he has filled a place in university life larger than that which most men occupy. He combines to a very unusual degree a fine literary and artistic taste with rare attainments of a scientific character. His popularity was never greater than it is to-day and his colleagues and students sincerely hope that he may long be spared to continue the work which for over thirty years he has done so efficiently and honorably.

APPLIED SCIENCE

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AND APPLIED CHEMISTRY AT THE UNIVERSITY OF TORONTO

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Editorial

Toronto's Opportunity

It had been our intention to write at length on the duty of every Toronto graduate, and undergraduate, in Applied Science and Engineering to take full advantage of the Annual Meeting of the Canadian Society of Civil Engineers which takes place in our city during the last week of this month. The letter of Mr. W. J. Francis, which is published in full on another page, renders this unnecessary. Everyone should read it carefully. For many years "Toronto" men have not interested themselves in the welfare of this great society as they should. The credit for the wonderful advances the society has made in the last few years must to a great extent be awarded to our friendly rival, McGill University, and its graduates. There are probably special reasons for this not apparent to us; but with this convention comes Toronto's opportunity. Let us not be slow in seizing it. Every third and fourth year man should between now and the date of the convention seek to identify himself with the society as a student member and endeavor to attend every meeting. It is not too much to expect that the council will call off lectures in these years, so that not only the undergraduates but the staff may have an opportunity of attending all sessions.

It is gratifying to know the Engineering Society is going to entertain the national body. Let this dinner be a success. Every "School" man should lend his presence and enthusiasm in making it so.

The Ideal Lecturer

Attention is again called to the essay on "The Ideal Lecturer." A full discussion on this subject from the standpoint of the undergraduate cannot help but be interesting and must be instructive. While there will be as many "ideals" as there are idealists, it is probable that they can be readily divided into classes according as they view the aim of an engineering education. On the one hand are those who take for their motto, "Knowledge is power." These attempt to cover just as much ground as possible in a limited time. The extreme example is the lecturer who has thoroughly covered his subject. He rushes to his class and the blackboard and the entire hour is taken in a race to give and copy notes, which are afterwards memorized by the students. Everything has reached such a mechanical level that the personal equation of the lecturer is almost entirely lost. His place could be almost taken by lantern slides and a phonograph, with about as good results.

On the other hand there are those who claim that the ultimate test of a man's efficiency is not what he knows but what he can do, and that it should therefore be the aim of an engineering education to produce men who have the power to solve the industrial and engineering problems of the day.

Thus the lecturer must not only give his classes permanent possession of those kinds of knowledge which are most essential, but he must also teach them how to use that knowledge just as a mechanic is taught to use his tools. A mistake is made in giving the student more than he can ever assimilate. He should be taught how to meet and solve problems, so that he can go out into the great world with a confidence that he can solve its problems, one by one.

While the personal equation of the lecturer will always be the pre-eminent factor of his success, he must have the power of imparting his knowledge. He should have some idea of the psychology of teaching, for after all engineering faculties are schools, not colleges. A good engineer will not necessarily make a successful lecturer. The real test of a lecture course is the amount of benefit the students derive from it and consequently the lecturer should frequently apply the written test. These tests offer splendid opportunities of inculcating habits of accuracy, reliability, clearness of expression, and he should insist that the work be carried out in such a manner that these benefits will result.

Personally the ideal lecturer will be a thorough master of his subject. He will be clear and forceful in his delivery. His lectures will be logically developed, his language perfect, his blackboard work neat and accurate; his personality will be such that he will gain the good will and confidence of his classes; while firm he will clothe his lectures with an interest that discipline in a college class will be a negligible quantity. Should for some reason or other he lose control he will be big enough and strong enough not to take a coward's advantage of his class to vent peevish spite or biting sarcasm on the class either as a whole or on the individual who cannot hit back. He will be genial and sympathetic, easily approachable, and will always encourage his students to come to him with their knotty problems and at the same time will encourage in them a spirit of original research.

The Reunion Dinner

Since the last issue of Applied Science most of the plans for the Twentieth Annual Dinner have been completed, only some minor details have yet to be arranged. The Canadian Society of Civil Engineers have graciously accepted the invitation extended to them by the Engineering Society. This in itself will give our annual function more than its ordinary significance.

The graduates have taken hold of their end of the plans with an energy, a will, and an enthusiasm, they have never before shown in connection with any of our functions. Some of them, who are busy men, are taking a holiday and coming a long distance to be in Toronto for that evening.

Among the undergraduates also there is a real live enthusiasm. Every one feels that this event marks a new era in the history of the Applied Science Faculty, for upon the success of this enterprise, to a large extent, depends the amount of influence wielded by the Engineering Society.

A. E. Nourse, '07, is with the Expanded Metal Co. of Canada.

We regret to note the death of James McDougall, B.A., who was one of the School's earliest graduates, having graduated in 1884. A full obituary will appear in our April issue.

Messrs. Sinclair and Smith (both S.P.S.) consulting engineers, have rearranged their business arrangements and work will now be carried on under the name of Sinclair, Sutcliffe & Neelands. H. W. Sutcliffe and E. W. are both '07 men.

SOME RANDOM THOUGHTS FROM THE TORONTO GRADUATES' DINNER.

F. H. CHESNUT

At the St. Charles Hotel on the evening of January 13th, a number of graduates (about 50 in all) of the Faculty of Applied Science again congregated to discuss such points of interest as might be brought forward in connection with the improvements of the course in Applied Science at Toronto University and also to consider the means by which the standing of the Engineer in this country may be improved.

The following paragraphs give in substance the proceedings of the meeting and also the writer's views on the subjects under discussion.

The first matter brought before the meeting was a plea for higher standing of matriculation into the Faculty of Applied Science.

Many persons have commented on the fact, that a very large percentage of the students of the first year fail in their examinations. What are the causes of this? The question may be answered by either one or all of the following:

(1) The papers may be too difficult.

This is unusual and may be eliminated.

(2) The student may not take enough interest in his work due to either carelessness (which then puts him on his own responsibility) or due to his being discouraged by the amount of new work which confronts him. This latter would not be the case had he obtained a thorough working knowledge of Algebra, Euclid, Trigonometry and Analytical Geometry. The fact of the matter is that the jump is too great from the standard of the High School to the standard of the first year Science.

(3) The student may not be of sufficient age to grasp the subjects of the first year. The only solution of this difficulty is the establishing of a standard of admission in this respect.

There is still another side to the question. It is claimed that even if the standard of entrance be raised that no material difference would be shown in the results of first year examinations. It seems reasonable to admit that in the natural course of things the standard of the first year examinations would be automatically raised and if so there would still be the long list of tail-enders.

Considering both sides of the question it would then appear that the raising of the standard would not materially effect the number of successful candidates at the first year examinations, but it will be admitted that an engineer with a thorough grounding in the subjects spoken of (which are indeed perhaps the only subject he remembers after leaving college) is in a position to handle the average problem which he meets in practice.

RELATIONS WITH FACULTY OF EDUCATION

It was next brought to the notice of the meeting that the requirements for entry to the Faculty of Education were such that a graduate holding the degree of B.A.Sc. was not eligible while on the the other hand, a holder of the certificate of Senior Matriculation was eligible.

This seems a rather peculiar state of affairs but no doubt exists through an oversight on the part of the Council of the Faculty of Education, and needs but a suggestion to them to be rectified.

Along this line it might be suggested that demonstrators and lecturers of the Faculty of Applied Science be required to take a course in the Faculty of Education before being eligible for positions on the staff. It must be admitted that such a course might do a world of good and at any rate is worth a trial.

A good suggestion was next brought forward regarding the proposed study of English in the new course which is being formulated by the Council.

It was suggested that a system of English recitation be adopted, by which it was meant that the student would be required to write reports on different engineering problems. For instance, the Civil section might be required to make a survey of the Ravine and report on the feasibility of a bridge or an embankment across it, giving reasons for and against each proposition. Reports should be logical and concise, thus teaching the student the use of English in the practice of engineering.

MATHEMATICS IN ENGINEERING

Following this was a discussion as to the amount of higher mathematics which the average graduate carries away with him when he leaves the College Halls.

The speaker advocated a thorough working knowledge of Analytical Geometry and the Calculus.

There is no doubt that in many ways an engineer who can apply the Calculus would be master of many a situation; but it must be admitted that the brain with which most of us are provided is one of limited capacity; and it is almost a well known fact that the man who has his brain loaded down with numberless formulae is usually unable to apply a tithe of what he knows. We will admit, however, that there are exceptions. It seems more reasonable, however, to use the Calculus as more of a mind trainer than as a subject to be considered seriously in the everyday life of a practical engineer.

The Faculty of Applied Science does not attempt to turn out machines into which are fed problems and out of which come answers; it rather attempts to turn out men who by their college education have become fitted to handle problems in a logical, business-like manner. When the young engineer leaves the life of school to enter the school of life he should realize that he has not a formula to apply to each problem but better still a reasoning brain to apply to all problems.

We should realize as young engineers that we cannot all be inventors of new thoughts and methods; other great minds have gone before us and by thought and research have discovered and established certain facts and in many cases compiled them in the convenient Hand Book form. Hence, a close study of the Hand Books on different subjects would be of far greater benefit to the student than an attempt to become proficient in deriving Taylor's Theorem.

THE STATUS OF THE ENGINEER

The next subject brought forward is one which will no doubt be within the limelight in this country in a short time. It is that of protection by law of the Engineering profession.

What is required is legislation preventing any one from calling himself an engineer without first having passed the examination set by an Engineering Council appointed by the Legislature.

Is there any more reason why the country should be protected against incompetent men practicing medicine than against incompetent men practicing engineering? Why should the municipalities, the railway companies, private individuals, or any person or persons who employ an engineer be subjected to loss of life, property and money due to the incompetence of the engineer? But this state does exist and always will exist until the status of the engineering profession is established.

Again, the engineer of good standing must protect himself, for if one of his profession or one who presumes to call himself an engineer makes a blunder due to insufficient knowledge, the whole profession is lowered in the eyes of the employing public.

The matter has reached such a state at the present time that all engineering organizations throughout the country should rise up and demand legislation and should also see that the act is rigidly enforced.

Among those present at the dinner were: '88—C. H. C. Wright; '89—D. D. James, H. E. T. Haultain; '90—R. A. Ross, Montreal; '91—R. W. Thomson; '92—C. F. Mitchell; '93—A. F. Macallum, A. L. McAllister, W. J. Francis; '95—A. W. Connor; '99—W. A. Hare; '00—W. F. Evans, F. W. Thorold; '03—S. B. Wass; '04—E. Wade, W. G. McFarlane; '05—T. R. London, W. G. Swan; '06—C. B. Hamilton, C. S. Dundass, F. Barber, D. E. Beynon, F. M. Byam, J. O. Roddick, J. C. Armer, W. L. Amos, E. M. Wood.

C. C. Forward, '06, has been appointed to the staff of the Dominion Analyst, at Ottawa.

WANTED—A qualified O. L. S. and two experienced bush transit men. Apply H. T. Routley, Haileybury, Ont.

THE CANADIAN SOCIETY OF CIVIL ENGINEERS.

The University of Toronto.

Dean Galbraith.

Montreal, Jan. 6th, 1909.

My Dear Mr. MacKenzie: —

In connection with the coming Annual Meeting of the Canadian Society of Civil Engineers, I would suggest that "Applied Science" say some very important things in the January number and say them in the most pointed language at your command. For this event, to which we are all looking forward with much interest, committees are working and individuals are working. Applied Science, however, stands in a very different relation to the great body of students and graduates from that occupied by committees and individual members who must necessarily work by themselves. Applied Science speaks to all and on this occasion it should speak with no uncertain sound. This Annual Meeting of the Canadian Society of Civil Engineers will be one of the most important in the history of that organization,—an organization which may easily lay claim to being the most important scientific body in the Dominion of Canada to-day. To it practically all the engineers of this great Dominion belong, and the leading engineers of Canada will be at the meeting. The chief officer of this important body is our honored Dean. The students and graduates of the Faculty of Applied Science and Engineering of the University of Toronto owe it to the Society, to the University and to Dr. Galbraith to make the coming meeting an event which will long be remembered with pleasure by all who may have the opporunity to attend.

The Annual Meeting arranged for the 28th, 29th and 30th instants, is the only the second that has been called outside of headquarters of the Society at Montreal. On the former occasion in 1906 the first outside annual meeting was an unqualified success. The next meeting should be and will be a still greater success, and it is indeed gratifying to note from the official programme that the members of the Canadian Society of Civil Engineers are to be entertained by the undergraduates at the great school reunion on the 28th inst. This is "Toronto's" opportunity. It has been my good fortune for many years to have the privilege of attending meetings at the headquarters of the Society, and to have observed with great pleasure the manner in which McGill has thrown itself into the work of that organization. The high standard of the Canadian Society of Civil Engineers to-day is largely due to the unstinted labors of many connected with the staff of the great Montreal University. McGill has done what she ought to have done and she has left undone those things she ought not to have done and her efforts are appreciated. The coming occasion will be **T-o-r-o-n-t-o's** first opportunity to show her regard for the Canadian Society of

Civil Engineers and assert herself in the eyes of the engineering profession.

The occasion has still greater interest for the S.P.S. men. Our honored Dean will preside at the Society meetings in his capacity as President, and at the close he will hand the reins of office to a worthy successor. An unusual opportunity is thus afforded to all "School" men to show to Canadian Engineers and to the world at large in a very tangible way how highly they esteem and revere that man whose name is dear to every one of us. No truer heart ever beat in human breast. No better friend ever existed than he. Let us show our hand. The name Galbraith will go down to history as having occupied one of the high places in engineering education and it is gratifying to think that he is yet in his prime to appreciate the position he holds in the hearts of his students and his graduates, and the esteem in which he is held by the profession generally.

I wish you would point out also the importance of the continual attendance at every meeting of the coming Convention of every member of the School staff connected with the Canadian Society of Civil Engineers. This may seem at first a difficult to thing to do, but they should bear in mind that a great number of men will be present from all parts of Canada at great expense to themselves, and, in comparison with these, the staff members are under no expense whatever. The opportunity has never occurred before in such a broad way. It may never occur again. They owe it to themselves, to the Society, to the School and to the Society's President to follow this suggestion.

If time would permit, I should like to say a word to the graduates of the School concerning their connection, or, rather lack of connection, with the great professional engineering body of Canada. There is altogether too much indifference on the part of Toronto Engineering graduates toward the Canadian Society of Civil Engineers. Comparatively speaking, very few applications are put in, and too many of those who have attained the grade of Associate membership are content to remain in that class after they are long fitted to rank as full members in which grade they would be welcomed by the Society. There is no reasonable excuse for this. Branches of the organization exist, one might say—from ocean to ocean. In their own behalf and in behalf of the profession the graduates should take an active interest in the Society's affairs. Connection with the Society is a privilege and an honor all should covet.

In conclusion, let me again say that you cannot point out too strongly the importance of "Toronto" asserting herself by interest and attendance at the coming annual convention. The parties concerned are a great professional body, a great academical body and a great man—the Canadian Society of Civil Engineers, the University of Toronto and John Galbraith.

Yours sincerely,

WALTER J. FRANCIS.